US008406738B2

(12) **United States Patent**
Harada et al.

(10) **Patent No.: US 8,406,738 B2**
(45) **Date of Patent: Mar. 26, 2013**

(54) **MOBILE TERMINAL AUTHENTICATION METHOD AND SYSTEM**

(75) Inventors: **Hiromi Harada**, Kawasaki (JP); **Tatsuhiro Ando**, Kawasaki (JP)

(73) Assignee: **Fujitsu Limited**, Kawasaki (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 395 days.

(21) Appl. No.: **12/781,321**

(22) Filed: **May 17, 2010**

(65) **Prior Publication Data**

US 2010/0330957 A1 Dec. 30, 2010

(30) **Foreign Application Priority Data**

Jun. 30, 2009 (JP) 2009-155512

(51) **Int. Cl.**
H04M 1/66 (2006.01)

(52) **U.S. Cl.** **455/411**; 455/406; 455/435.1; 370/338; 370/401

(58) **Field of Classification Search** 455/406, 455/411, 432.1, 435.1; 370/328, 338, 401
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,522,907	B2 *	4/2009	Lupper et al.	455/411
7,856,226	B2 *	12/2010	Wong et al.	455/414.1
7,885,654	B2 *	2/2011	Fadell	455/435.2
8,194,540	B2 *	6/2012	Kim et al.	370/230
8,213,934	B2 *	7/2012	Tsirtsis et al.	455/435.1
8,228,861	B1 *	7/2012	Nix	370/329
2004/0017798	A1	1/2004	Hurtta et al.	
2004/0162058	A1 *	8/2004	Mottes	455/411
2005/0260997	A1	11/2005	Korale et al.	
2008/0070570	A1 *	3/2008	Jiang	455/433
2010/0017861	A1 *	1/2010	Krishnaswamy et al.	726/7
2010/0232407	A1 *	9/2010	Navali et al.	370/338

FOREIGN PATENT DOCUMENTS

JP	2003-534714	11/2003
JP	2005-539462	12/2005
JP	2007-235495	9/2007

* cited by examiner

Primary Examiner — Sharad Rampuria
(74) *Attorney, Agent, or Firm* — Staas & Halsey LLP

(57) **ABSTRACT**

A method and system of authenticating a mobile terminal may include using a Mobile Virtual Network Operator (MVNO) authentication device managed by a mobile virtual network operator, receiving an authentication request sent from the mobile terminal from a relay device via a MVNO base station configured to provide a service of the mobile virtual network operator, where the relay device is located between the MVNO base station or a Mobile Network Operator (MNO) base station configured to provide a service of a mobile network operator and the MVNO authentication device or a MNO authentication device managed by the mobile network operator, and determining whether or not access from the mobile terminal, as a MVNO mobile terminal registered as a user of the mobile virtual network operator, based on the authentication request is permitted.

14 Claims, 15 Drawing Sheets

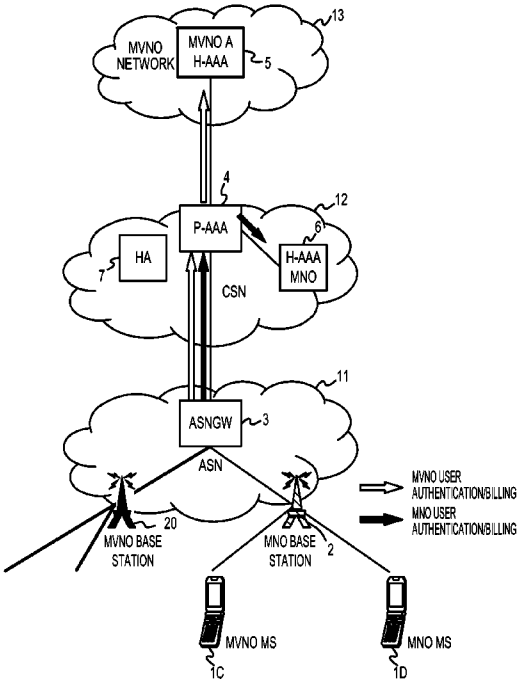


FIG.1
-RELATED ART-

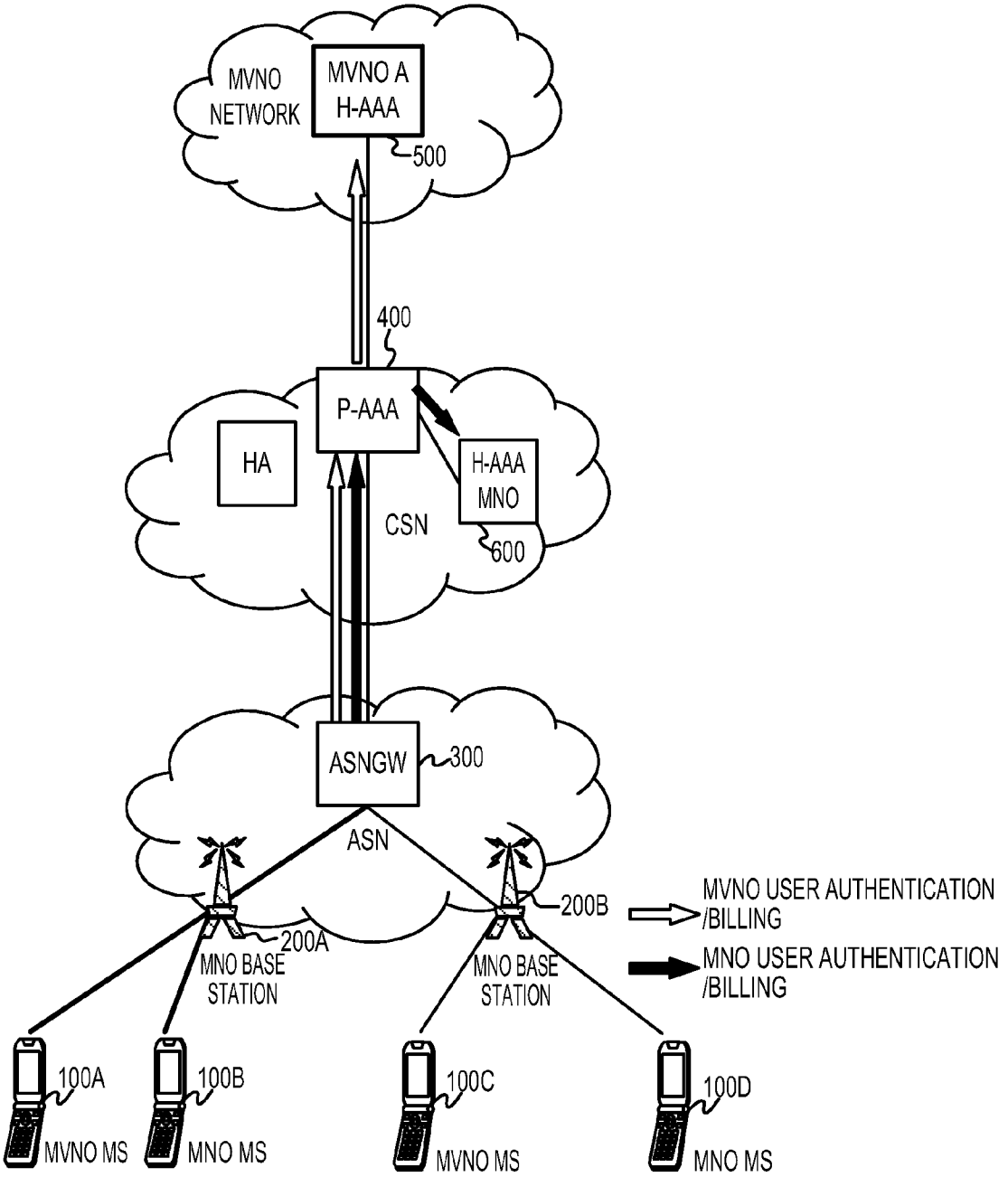


FIG.2

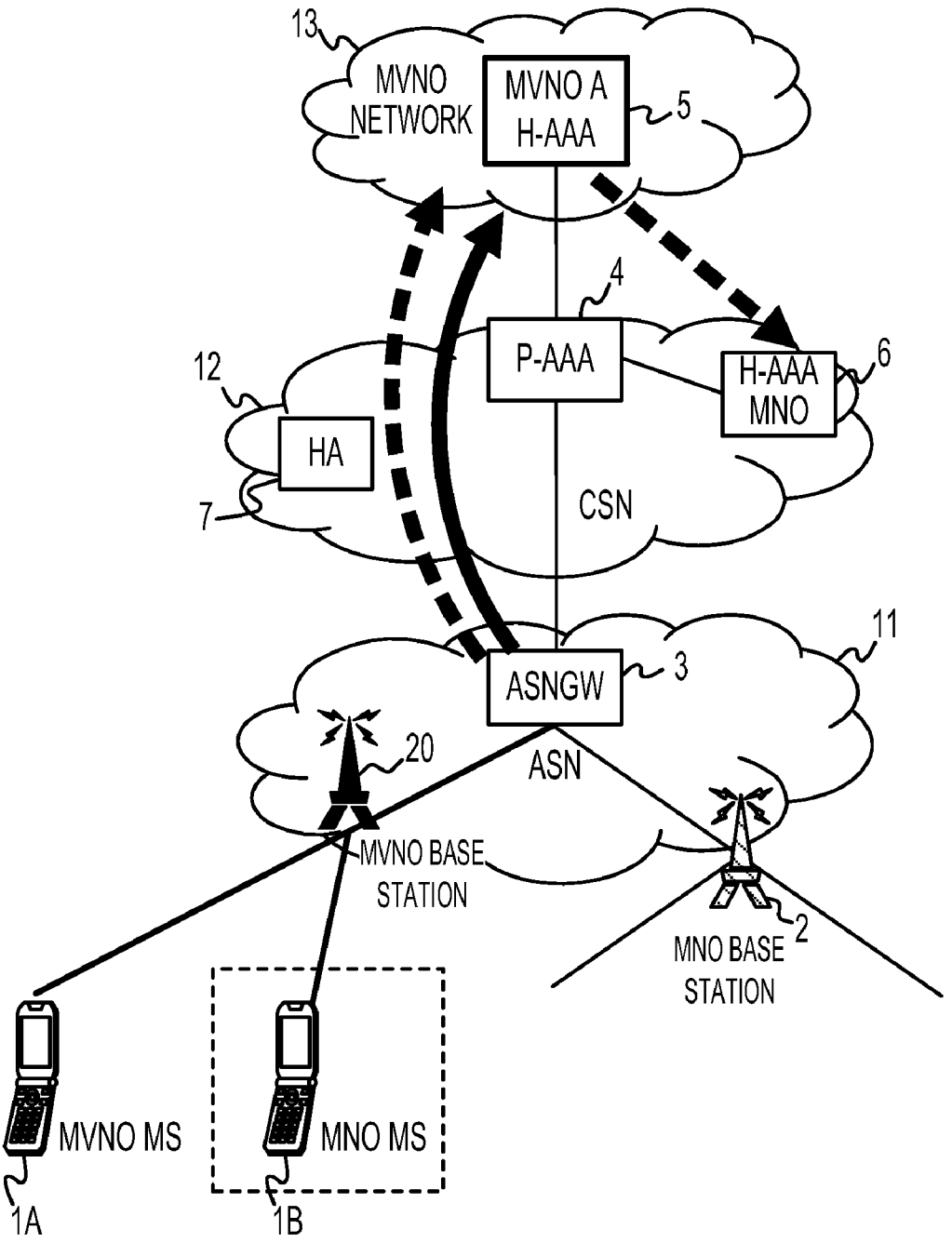

13
MVNO NETWORK
MVNO A H-AAA
5
4
P-AAA
H-AAA MNO
6
12
HA
7
CSN
11
ASNGW
3
20
ASN
MVNO BASE STATION
MNO BASE STATION
2
MVNO MS
MNO MS
1A
1B

FIG.3

FIG. 3A
FIG. 3B

FIG.3A

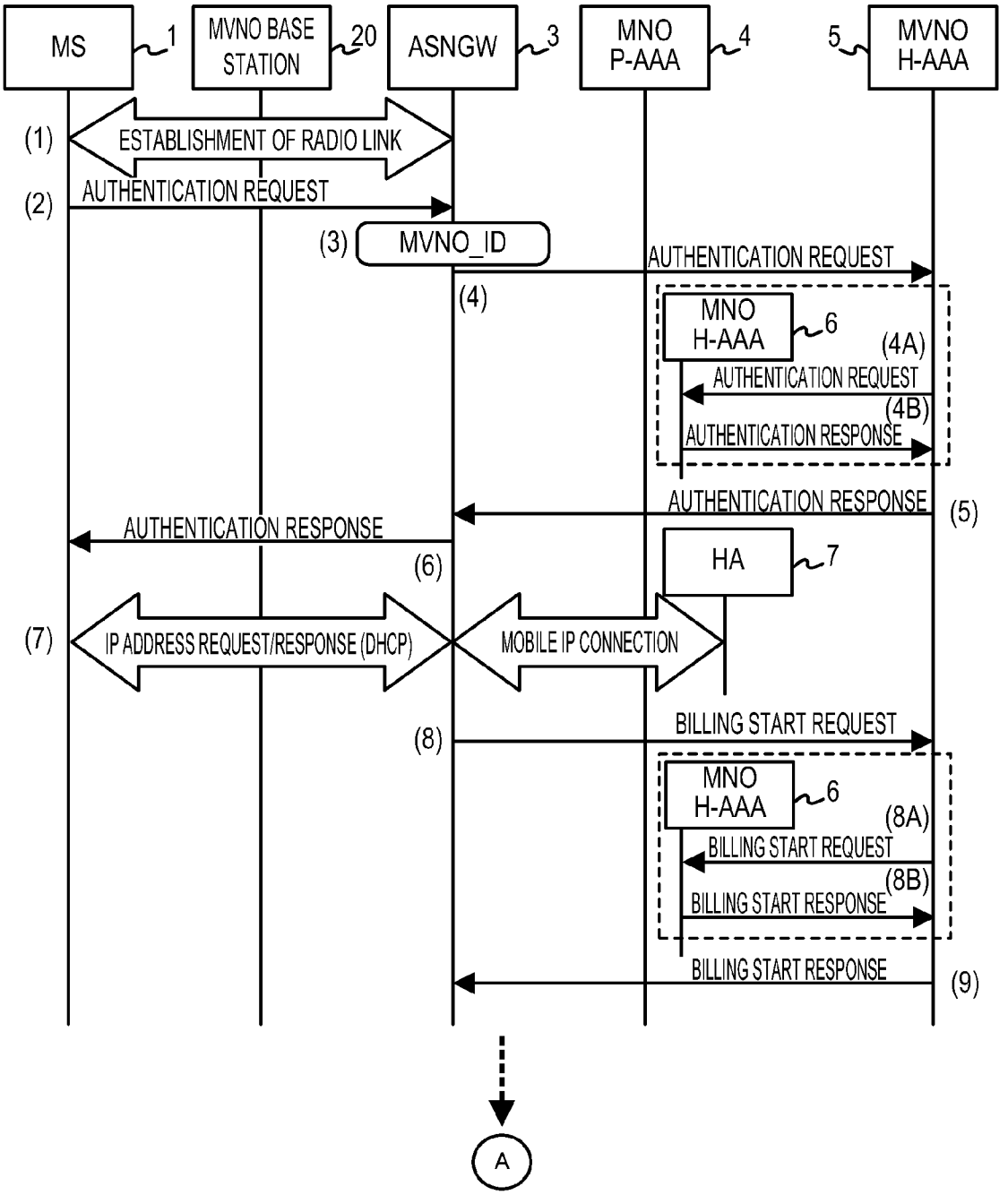


FIG.3

FIG. 3A
FIG. 3B

FIG.3B

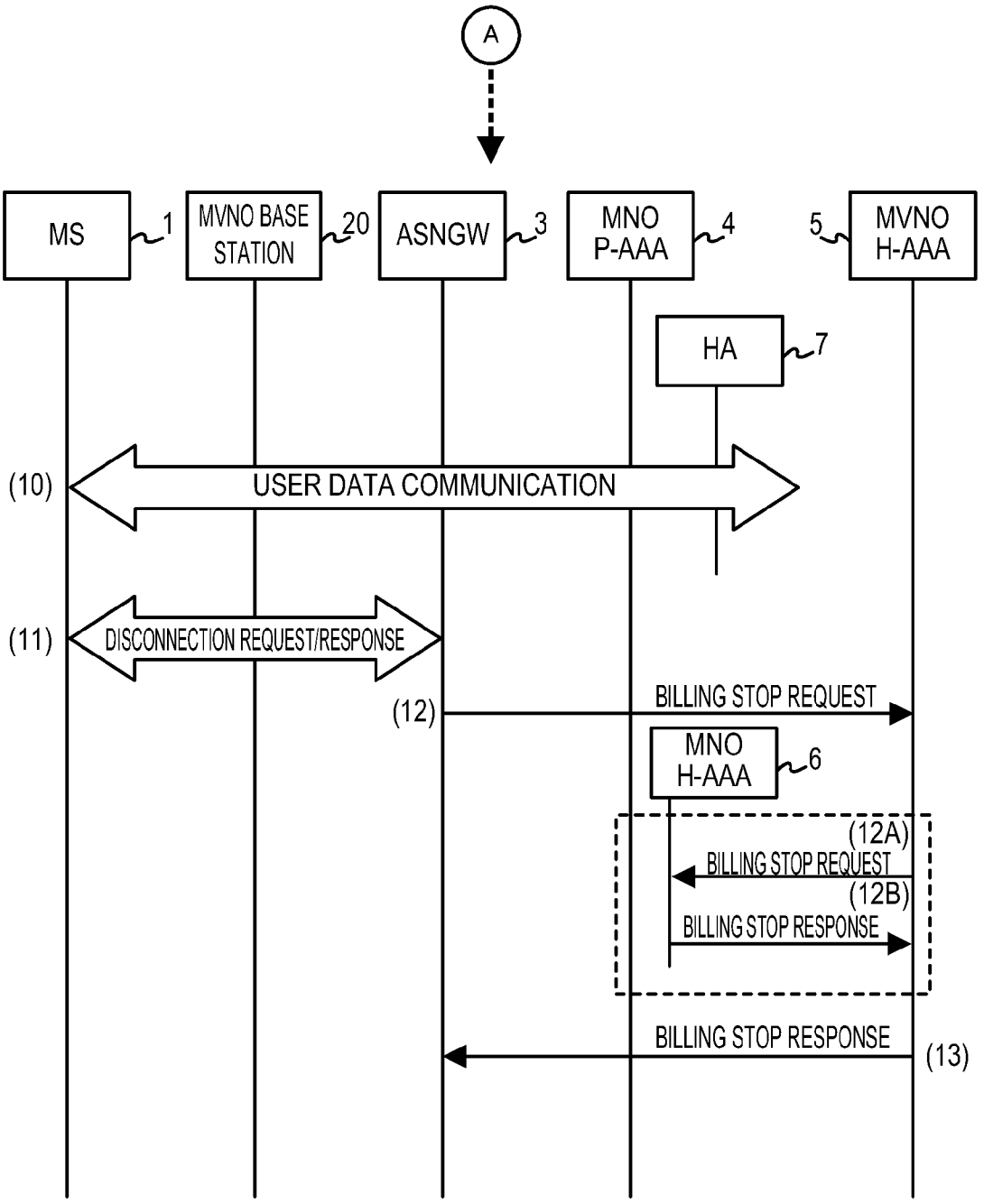


FIG.4

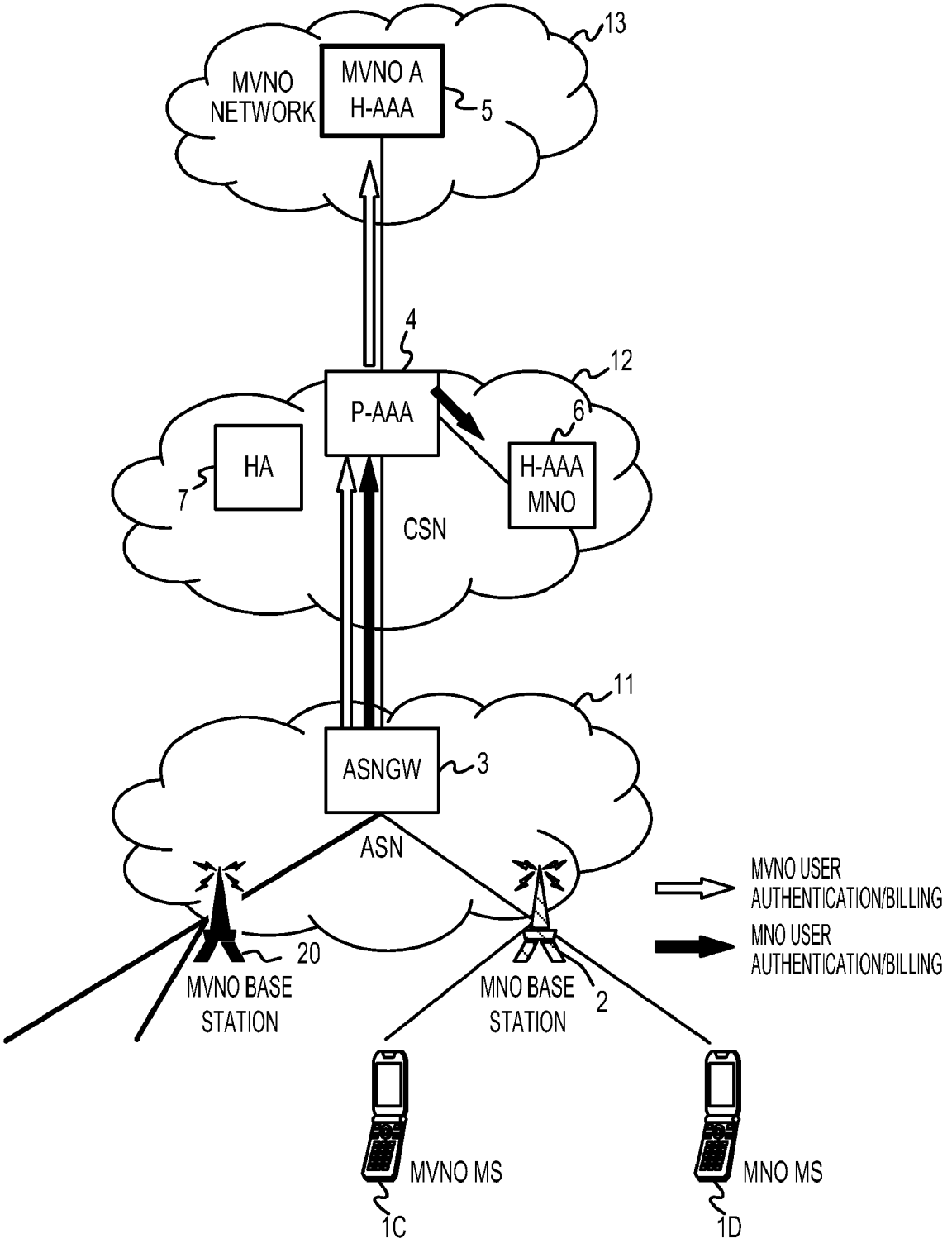

13
MVNO NETWORK
MVNO A H-AAA
5
4
12
P-AAA
6
HA
7
H-AAA MNO
CSN
11
ASNGW
3
ASN
MVNO USER AUTHENTICATION/BILLING
MNO USER AUTHENTICATION/BILLING
20
MVNO BASE STATION
MNO BASE STATION
2
MVNO MS
1C
MNO MS
1D

FIG.5

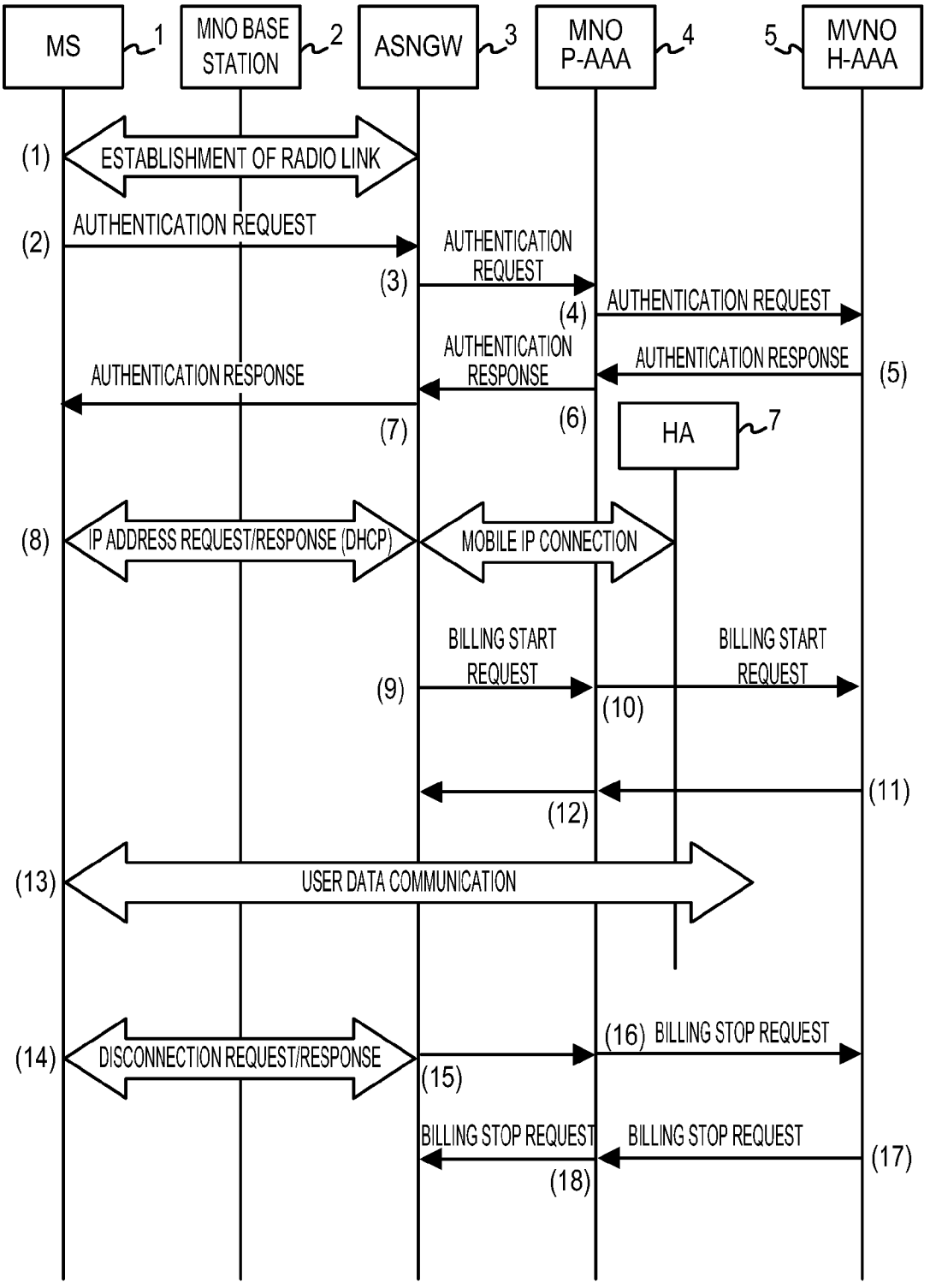

MS
1
MNO BASE STATION
2
ASNGW
3
MNO P-AAA
4
5
MVNO H-AAA
(1)
ESTABLISHMENT OF RADIO LINK
(2)
AUTHENTICATION REQUEST
AUTHENTICATION REQUEST
(3)
AUTHENTICATION REQUEST
(4)
AUTHENTICATION RESPONSE
AUTHENTICATION RESPONSE
(5)
AUTHENTICATION RESPONSE
(6)
HA
7
(7)
(8)
IP ADDRESS REQUEST/RESPONSE (DHCP)
MOBILE IP CONNECTION
BILLING START REQUEST
BILLING START REQUEST
(9)
(10)
(11)
(12)
(13)
USER DATA COMMUNICATION
(14)
DISCONNECTION REQUEST/RESPONSE
(15)
(16) BILLING STOP REQUEST
BILLING STOP REQUEST
BILLING STOP REQUEST
(17)
(18)

FIG.6

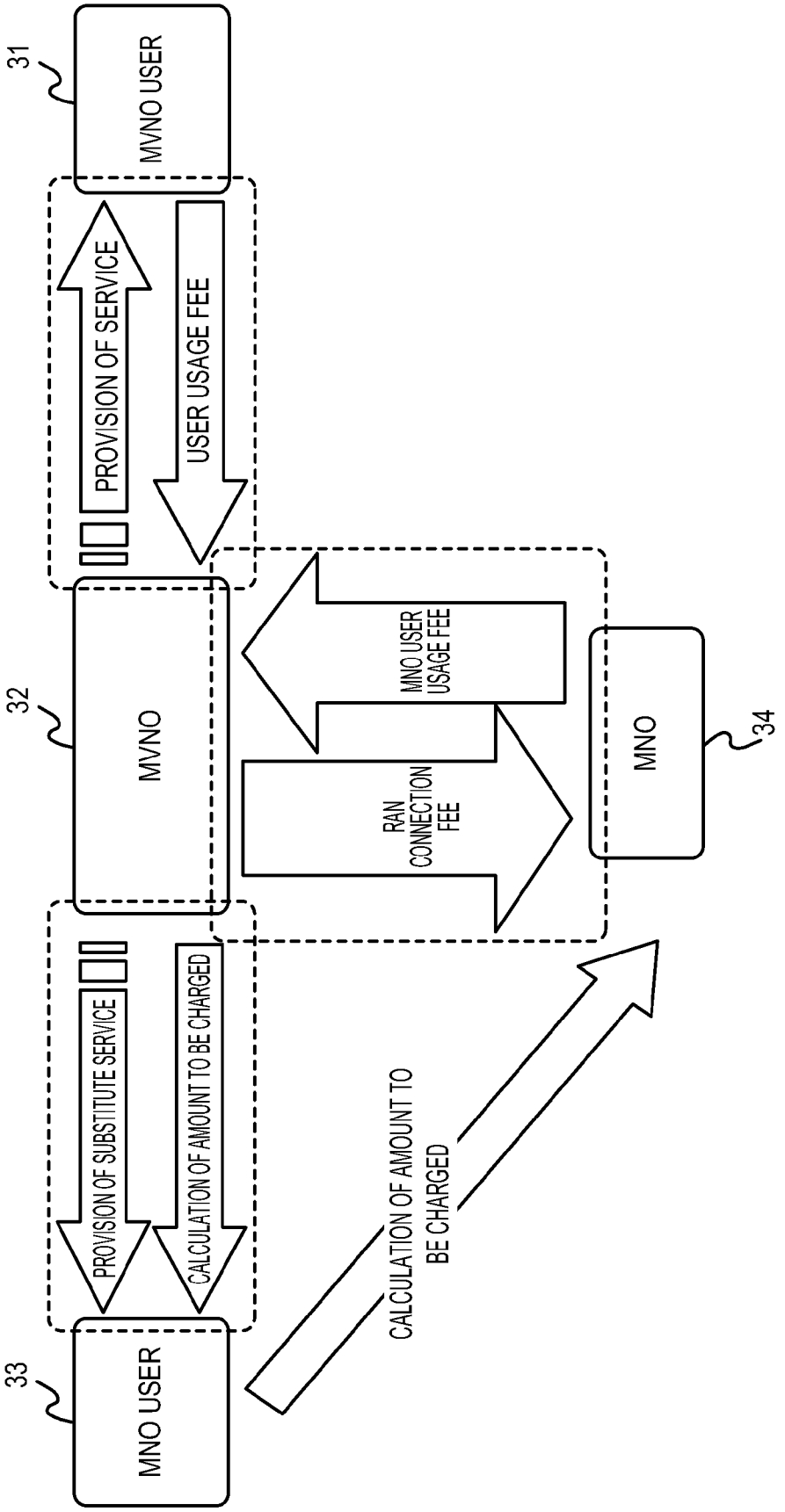

31
MVNO USER
PROVISION OF SERVICE
USER USAGE FEE
32
MVNO
MNO USER USAGE FEE
RAN CONNECTION FEE
MNO
34
PROVISION OF SUBSTITUTE SERVICE
CALCULATION OF AMOUNT TO BE CHARGED
CALCULATION OF AMOUNT TO BE CHARGED
33
MNO USER

FIG.7

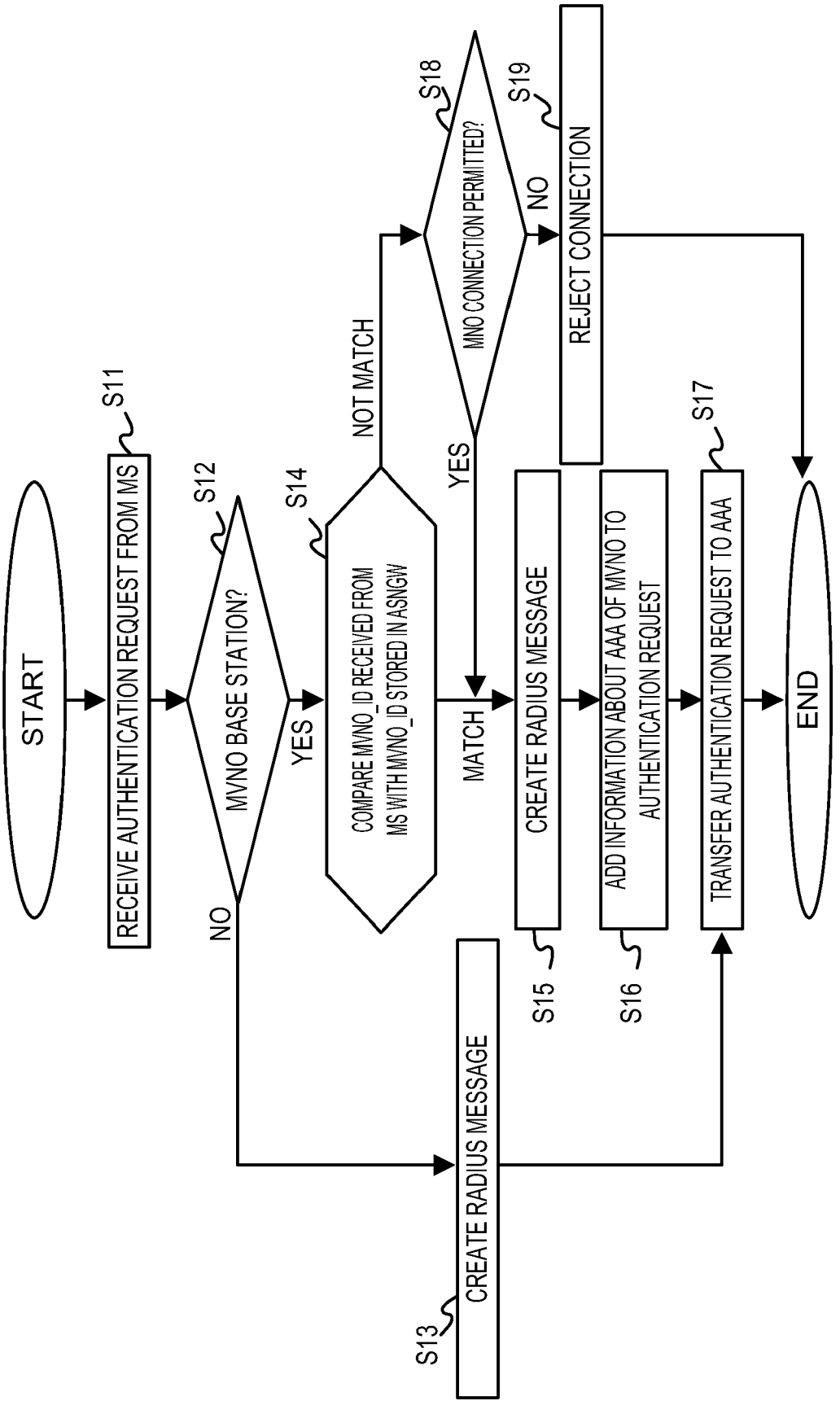

START
RECEIVE AUTHENTICATION REQUEST FROM MS
S11
MVNO BASE STATION?
S12
NO
YES
COMPARE MVNO_ID RECEIVED FROM MS WITH MVNO_ID STORED IN ASNGW
S14
NOT MATCH
MATCH
MNO CONNECTION PERMITTED?
S18
NO
YES
REJECT CONNECTION
S19
CREATE RADIUS MESSAGE
S15
ADD INFORMATION ABOUT AAA OF MVNO TO AUTHENTICATION REQUEST
S16
TRANSFER AUTHENTICATION REQUEST TO AAA
S17
CREATE RADIUS MESSAGE
S13
END

FIG.8

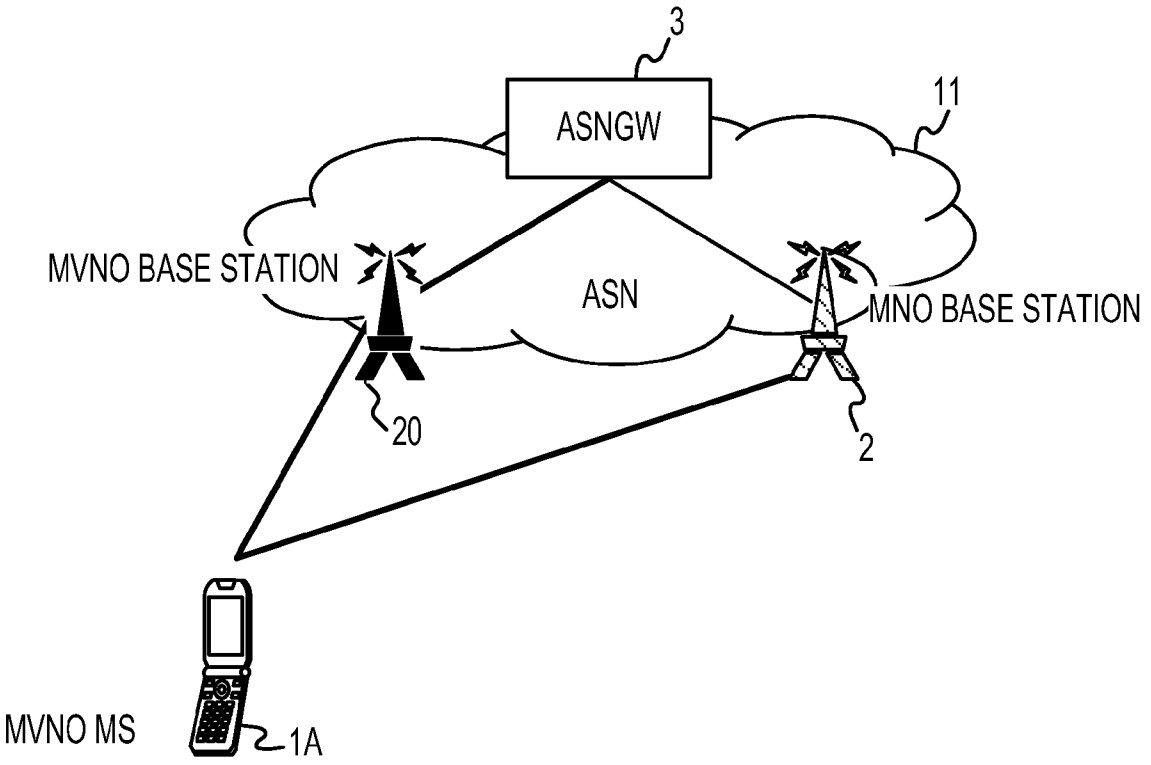

3
ASNGW
11
MVNO BASE STATION
ASN
MNO BASE STATION
20
2
MVNO MS
1A

FIG.9

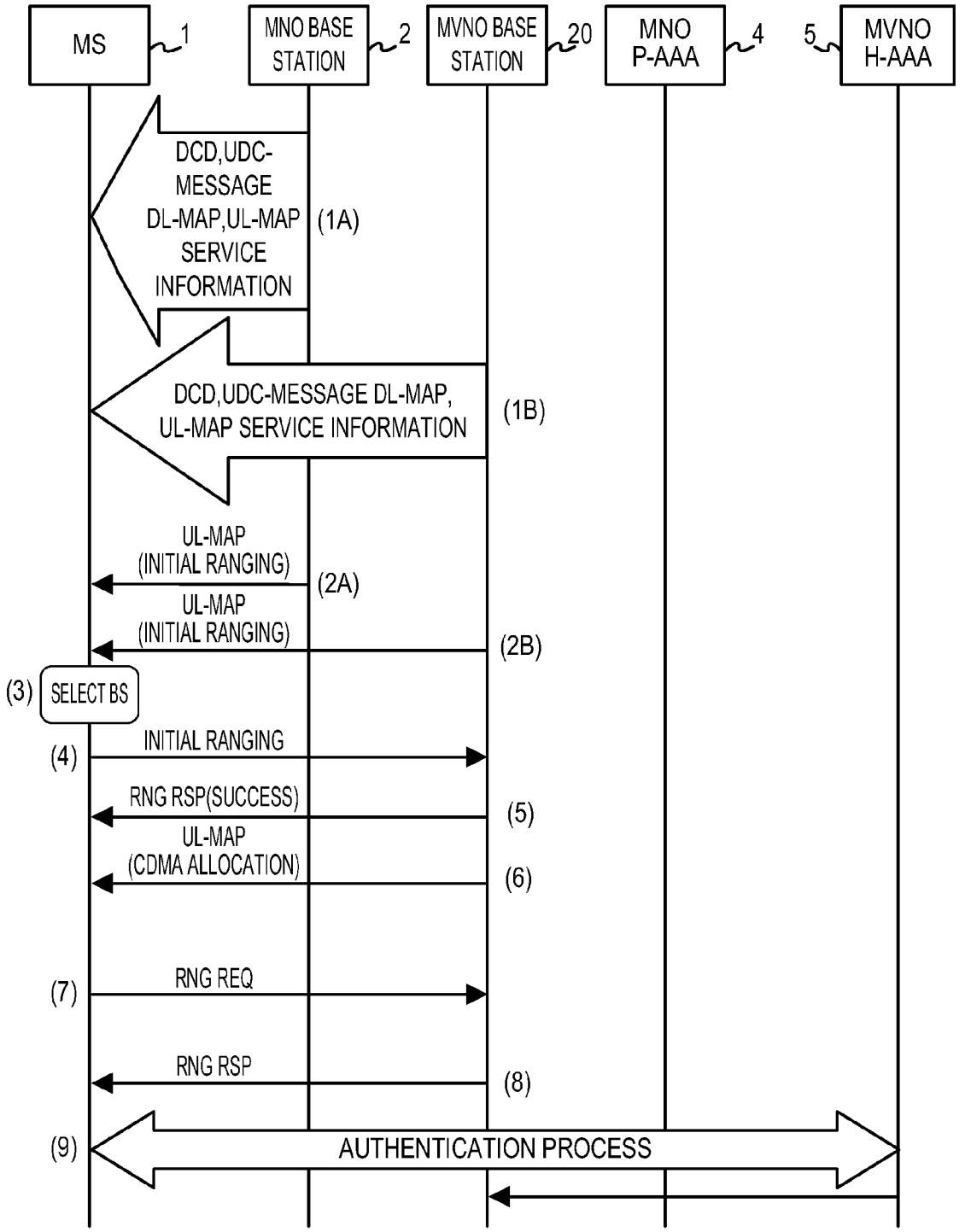

MS
1
MNO BASE STATION
2
MVNO BASE STATION
20
MNO P-AAA
4
5
MVNO H-AAA
DCD,UDC-MESSAGE DL-MAP,UL-MAP SERVICE INFORMATION
(1A)
DCD,UDC-MESSAGE DL-MAP, UL-MAP SERVICE INFORMATION
(1B)
UL-MAP (INITIAL RANGING)
(2A)
UL-MAP (INITIAL RANGING)
(2B)
(3)
SELECT BS
(4)
INITIAL RANGING
RNG RSP(SUCCESS)
(5)
UL-MAP (CDMA ALLOCATION)
(6)
(7)
RNG REQ
RNG RSP
(8)
(9)
AUTHENTICATION PROCESS

FIG.10

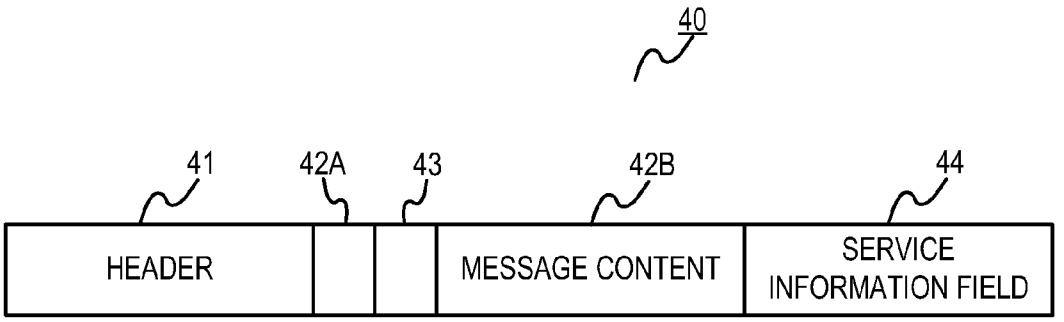

40
41
42A
43
42B
44
HEADER
MESSAGE CONTENT
SERVICE INFORMATION FIELD

FIG.11

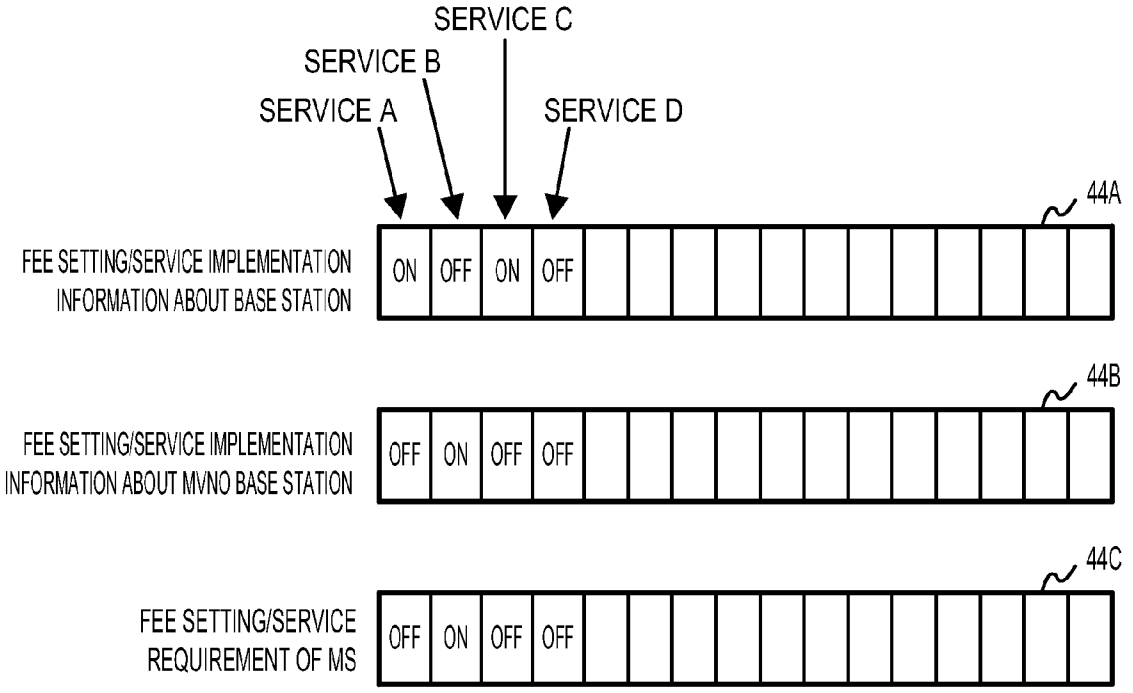

SERVICE C
SERVICE B
SERVICE A
SERVICE D
44A
FEE SETTING/SERVICE IMPLEMENTATION INFORMATION ABOUT BASE STATION
ON OFF ON OFF
44B
FEE SETTING/SERVICE IMPLEMENTATION INFORMATION ABOUT MVNO BASE STATION
OFF ON OFF OFF
44C
FEE SETTING/SERVICE REQUIREMENT OF MS
OFF ON OFF OFF

FIG.12

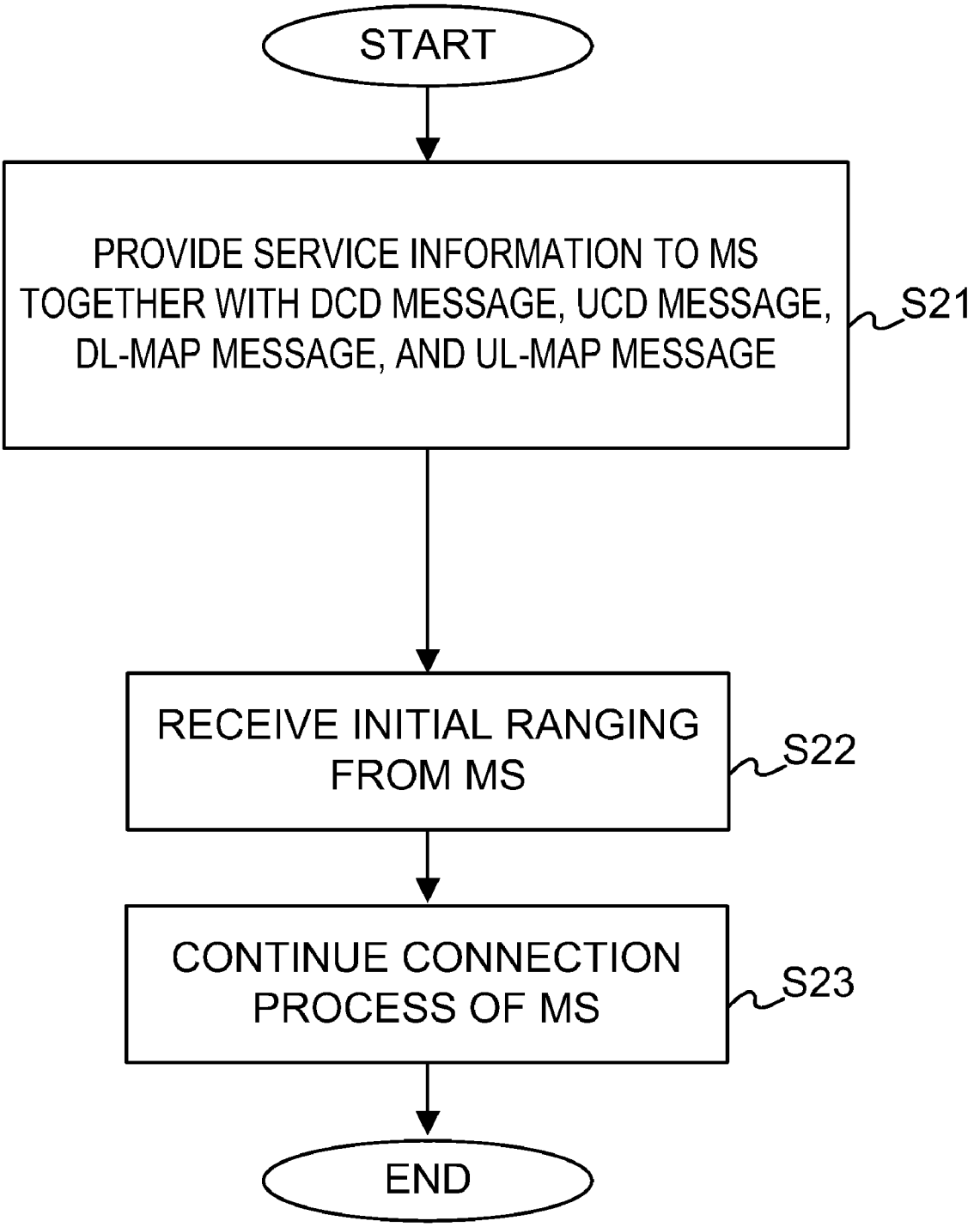

START
PROVIDE SERVICE INFORMATION TO MS TOGETHER WITH DCD MESSAGE, UCD MESSAGE, DL-MAP MESSAGE, AND UL-MAP MESSAGE
S21
RECEIVE INITIAL RANGING FROM MS
S22
CONTINUE CONNECTION PROCESS OF MS
S23
END

FIG.13

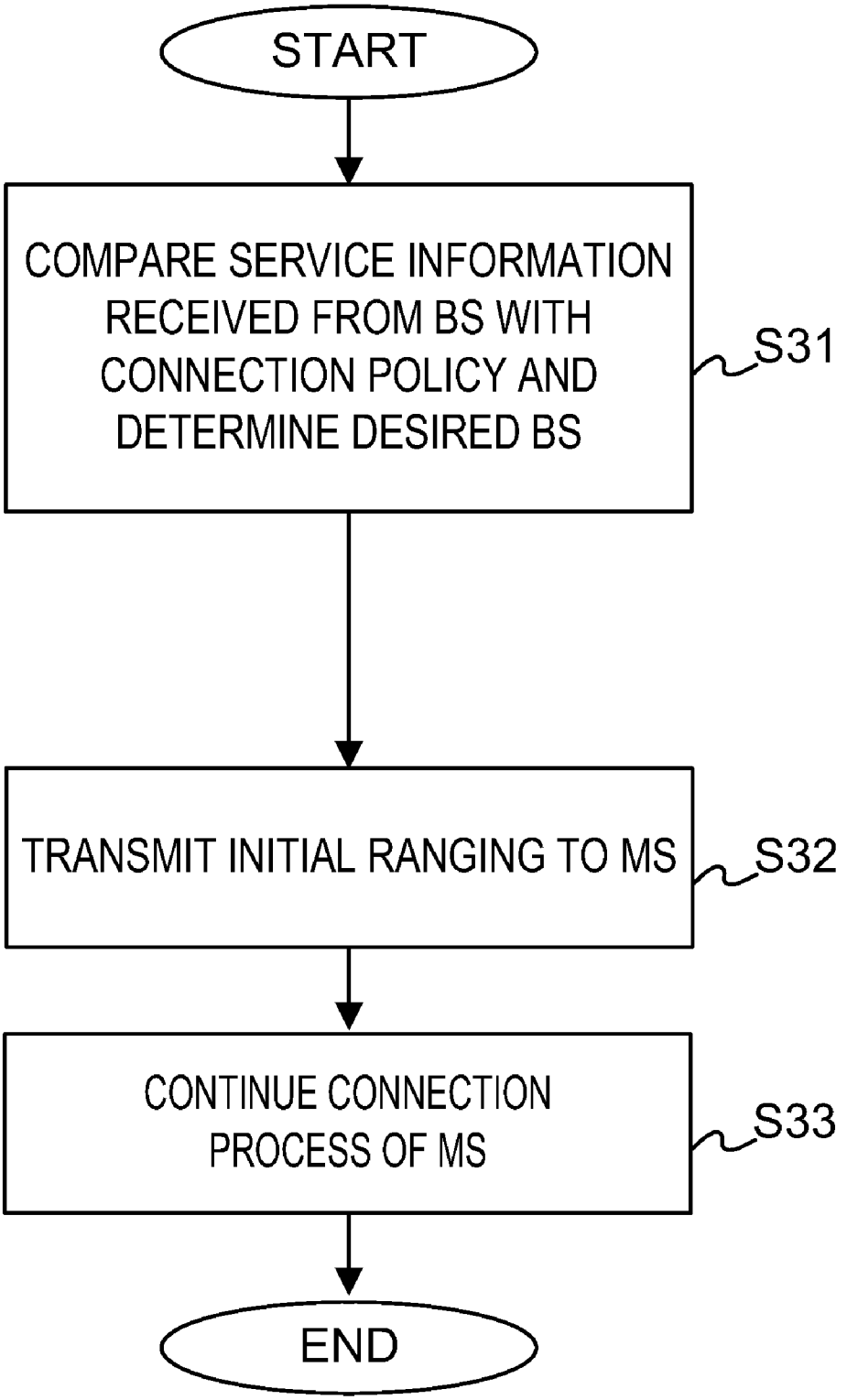

START
COMPARE SERVICE INFORMATION RECEIVED FROM BS WITH CONNECTION POLICY AND DETERMINE DESIRED BS
S31
TRANSMIT INITIAL RANGING TO MS
S32
CONTINUE CONNECTION PROCESS OF MS
S33
END

FIG.14

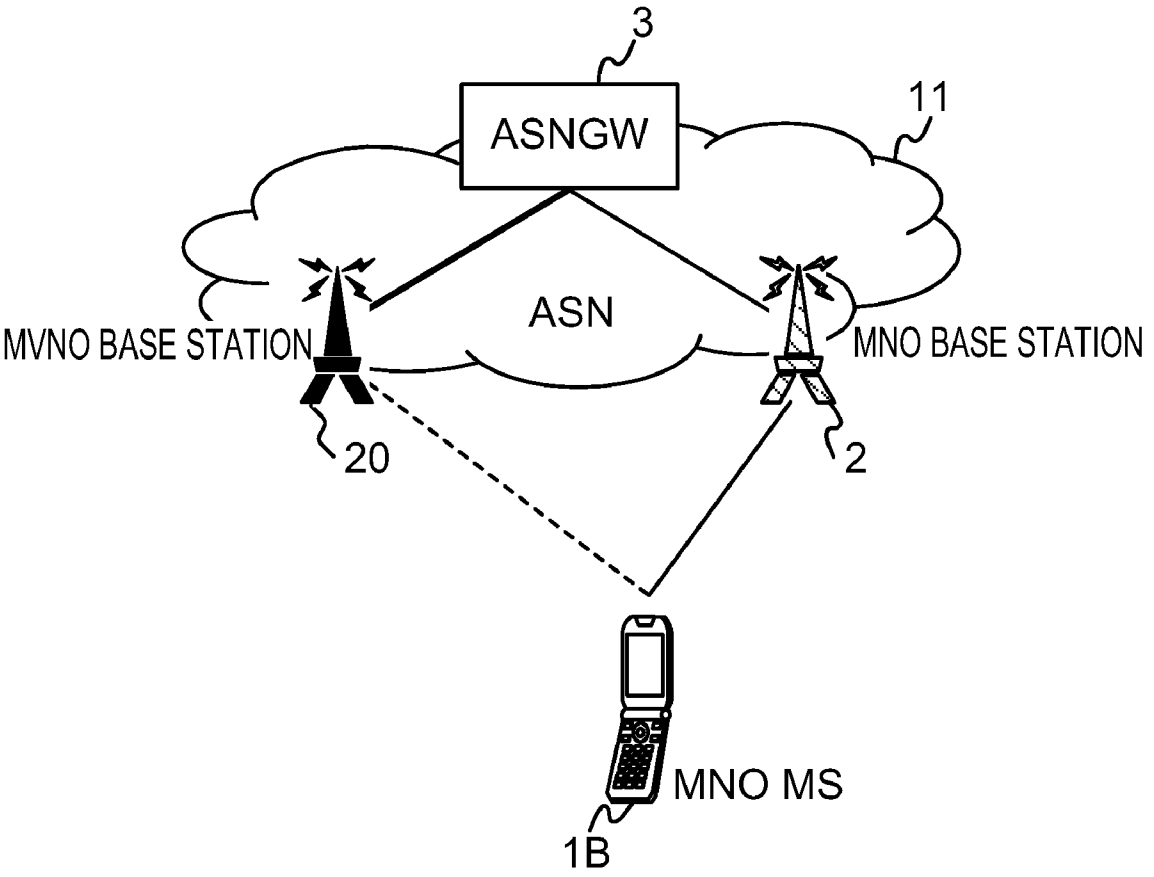
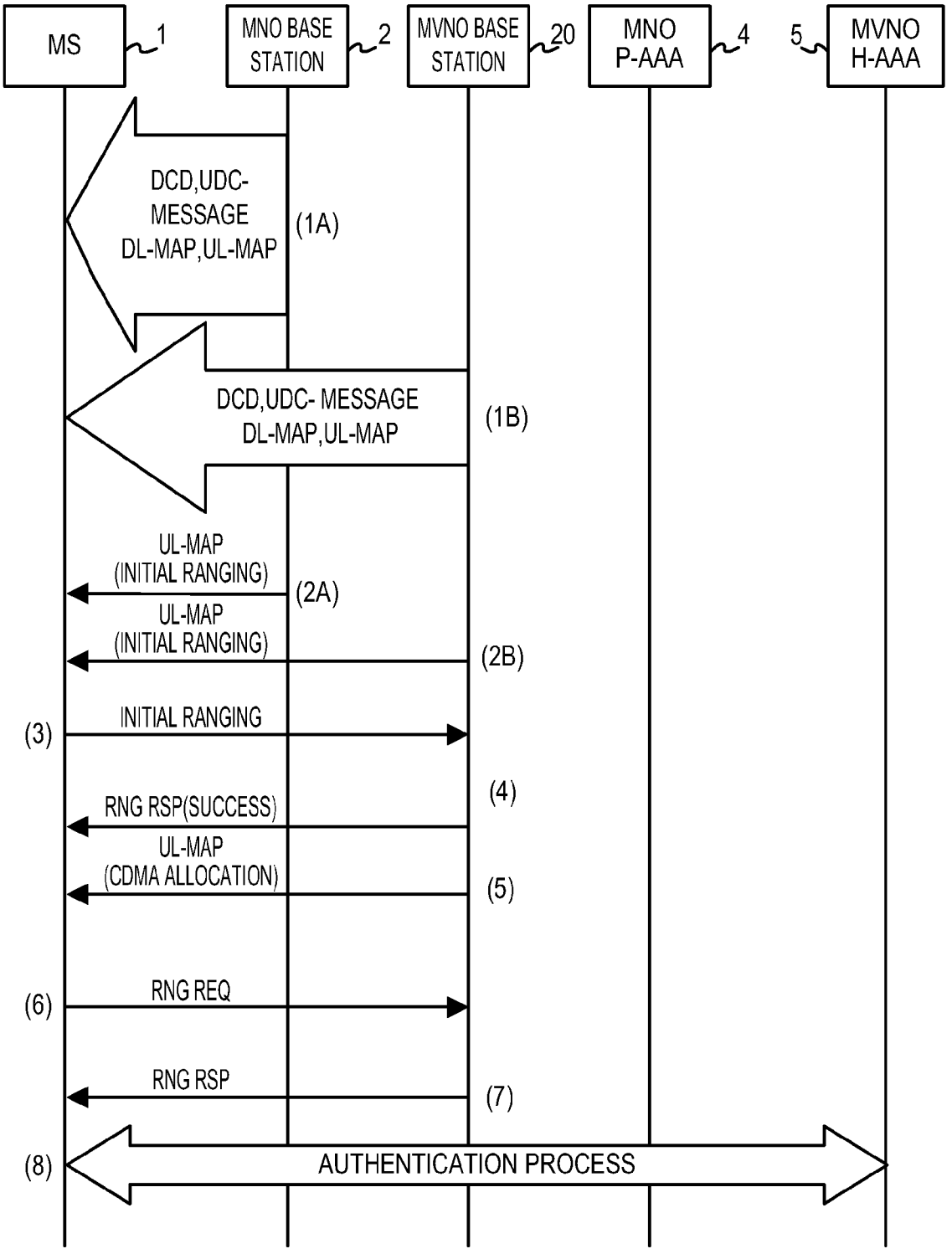

3
ASNGW
11
ASN
MVNO BASE STATION
MNO BASE STATION
20
2
MNO MS
1B

FIG.15


MS
1
MNO BASE STATION
2
MVNO BASE STATION
20
MNO P-AAA
4
5
MVNO H-AAA
DCD,UDC-MESSAGE DL-MAP,UL-MAP
(1A)
DCD,UDC- MESSAGE DL-MAP,UL-MAP
(1B)
UL-MAP (INITIAL RANGING)
(2A)
UL-MAP (INITIAL RANGING)
(2B)
(3)
INITIAL RANGING
(4)
RNG RSP(SUCCESS)
UL-MAP (CDMA ALLOCATION)
(5)
(6)
RNG REQ
RNG RSP
(7)
(8)
AUTHENTICATION PROCESS

MOBILE TERMINAL AUTHENTICATION METHOD AND SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2009-155512 filed on Jun. 30, 2009, the entire contents of which are incorporated herein by reference.

FIELD

Various embodiments disclosed herein relate to a method and system of authentication and billing of terminal(s) in a radio access network.

BACKGROUND

With the recent prevalence of mobile terminals such as cellular phones, various companies have provided communication service. Providers of communication service include Mobile Network Operators (MNOs) and Mobile Virtual Network Operators (MVNOs). Generally, MNOs are companies that have their own facilities for setting up radio access networks, such as base stations. MVNOs are companies that do not have their own facilities such as base stations and that lease facilities from MNOs to deploy service. The MVNOs handle authentication of MVNO users and billing of usage fees but are not responsible for control or the like of base stations.

FIG. **1** is a diagram illustrating an example of user authentication and billing involved when mobile terminals **100** (**100***a*, **100***b*, **100***c*, and **100***d*) use a radio access network. In FIG. **1**, MS stands for Mobile Station. In the illustrated example, it is assumed that the mobile terminals **100***a* and **100***c* are MVNO user terminals and that the mobile terminals **100***b* and **100***d* are MNO user terminals. The mobile terminals **100** transmit authentication request messages to an Access Service Network Gateway (ASNGW) **300** serving as a relay device via MNO base stations **200** (**200***a* and **200***b*) controlled by a MNO. The ASNGW **300** transfers the authentication request messages to a Proxy Authentication Authorization Accounting Server (P-AAA server) **400**. The P-AAA server **400** sorts the authentication request messages in accordance with whether each of the mobile terminals **100** is a MNO user terminal or a MVNO user terminal. For example, upon receipt of authentication requests from the mobile terminals **100***a* and **100***c* that are MVNO user terminals, the P-AAA server **400** transfers the authentication request messages to a Home Authentication Authorization Accounting (H-AAA) server **500** of a MVNO. The H-AAA server **500** performs authentication of MVNO users and handles charges to MVNO users. On the other hand, the mobile terminals **100***b* and **100***d* are mobile terminals **100** of MNO users. Thus, upon receipt of authentication request messages from the mobile terminals **100***b* and **100***d*, the P-AAA server **400** transfers the authentication request messages to an H-AAA server **600** of the MNO. The H-AAA server **600** of the MNO performs authentication of MNO users and charging to MNO users.

In the related art, for example, Japanese National Publication of International Patent Application No. 2005-539462 describes a radio network control device having independent resource controllers for each operator. It is discussed that the resource controllers allocate radio resource to a subscriber unit in response to an operator ID associated with a service of the subscriber unit so that different qualities of service are achieved for different operators. Furthermore, for example, Japanese Laid-open Patent Publication No. 2007-235495 discusses a base station control device including a database for registering accessible areas for each operator ID of a mobile terminal. In addition, for example, Japanese National Publication of International Patent Application No. 2003-534714 discusses a network including a network element that stores a list of selectable network elements. It is discussed that this list is accessed using an identifier for identifying a routing area, a location area, or the like.

As described above, the authentication request messages transmitted from the mobile terminals **100** are sorted by the P-AAA server **400** of the MNO to the H-AAA servers **500** and **600** of the operators that provide service to the mobile terminals **100**. Thus, it may be difficult for the MVNO to perform authentication or billing related processing using information other than the information sent from the mobile terminals **100** to the P-AAA server **400** of the MNO. The MVNO is not enabled to customize authentication or billing related method as desired.

SUMMARY

In accordance with an embodiment, a method of authenticating a mobile terminal using a Mobile Virtual Network Operator (MVNO) authentication device managed by a mobile virtual network operator is provided. The method includes receiving an authentication request sent from the mobile terminal from a relay device via a MVNO base station configured to provide a service of the mobile virtual network operator, where the relay device being located between the MVNO base station or a Mobile Network Operator (MNO) base station configured to provide a service of a mobile network operator and the MVNO authentication device or a MNO authentication device managed by the mobile network operator, and determining whether access from the mobile terminal, as a MVNO mobile terminal registered as a user of the mobile virtual network operator, based on the authentication request is permitted.

An object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the various embodiments, as claimed.

Additional aspects and/or advantages will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and/or other aspects and advantages will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings of which:

FIG. **1** is a diagram illustrating an example of user authentication and billing involved when a mobile terminal uses a radio access network;

FIG. **2** is a diagram illustrating an example of an operation performed in an authentication and billing method via a MVNO base station;

FIGS. **3**A and **3**B are sequence diagrams illustrating examples of an operation for authentication and billing of a mobile terminal via a MVNO base station;

FIG. **4** is a diagram illustrating an example of an operation performed when a mobile terminal requests authentication via a MNO base station;

FIG. **5** is a sequence diagram illustrating an example of an operation for authentication and billing of a mobile terminal via a MNO base station;

FIG. **6** is a diagram illustrating an example of a payment method for a fee generated for charging for communication performed via a MVNO base station;

FIG. **7** is a flowchart illustrating an example of an operation of an ASNGW;

FIG. **8** is a diagram illustrating an example of a method for allowing a base station to select a desired mobile terminal;

FIG. **9** is a sequence diagram illustrating an example of an operation performed when a mobile terminal selects a desired base station;

FIG. **10** is a diagram illustrating an example of a notification signal broadcast from a base station;

FIG. **11** is a diagram illustrating an example of a service information field and a connection policy of a mobile terminal;

FIG. **12** is a flowchart illustrating an example of an operation of a base station in a connection method that allows a selection of a base station;

FIG. **13** is a flowchart illustrating an example of an operation of a mobile terminal in a connection method that allows a selection of a base station;

FIG. **14** is a sequence diagram illustrating an example of an operation performed when a mobile terminal is connected to a MNO base station; and

FIG. **15** is a sequence diagram illustrating an example of an operation performed when a mobile terminal is connected to a MNO base station.

DETAILED DESCRIPTION

Reference will now be made in detail to the embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. The embodiments are described below to explain the present invention by referring to the figures.

A system illustrated in FIGS. **2**, **3**A, **3**B, **4** and **5** includes at least two types of base stations: a MNO base station **2** and a MVNO base station **20**. In the following description, it is assumed that, based on agreements or the like between a MNO and a MVNO, the MVNO is allowed to set or change the content or the like of messages sent and received via the MVNO base station **20**. Depending on the agreements between the MNO and the MVNO, the operation of MVNO base stations may be performed by the MVNO in place of the MNO, or the MVNO may ask the MNO to install a MVNO base station.

In the system illustrated in FIGS. **2**, **3**A, **3**B, **4** and **5**, an ASNGW **3** serving as a relay device determines a transfer destination of a control message transmitted from a mobile terminal **1** in accordance with whether the control message has passed through the MVNO base station **20** or the MNO base station **2**. Examples of the control message may include an authentication request message and a billing start request message. When the control message has passed through the MVNO base station **20**, the ASNGW **3** transfers the control message to an H-AAA server **5** of the MVNO. That is, the P-AAA server **4** of the MNO is not required to sort control messages sent via the MVNO base station **20**. Thus, a message sent via the MVNO base station **20** may include information that is not requested by the MNO, or may have a configuration different from a message used by the MNO. Therefore, the MVNO may select information used for authentication or billing from a wide range, and may easily customize the authentication method, the billing method, and the like. An example of the operation performed in an authentication and billing method according to an embodiment will be described in the context of four cases with reference to FIGS. **2**, **3**A, **3**B, **4** and **5**. In the following description, it is assumed that one MVNO and one MNO provide individual service.

FIG. **2** is a diagram illustrating an example of the operation performed in an authentication and billing method via a MVNO base station. A system illustrated in FIG. **2** includes an Access Service Network (ASN) **11**, a Connectivity Service Network (CSN) **12**, and a MVNO network **13**. In the illustrated system, a MVNO identifier for uniquely identifying the MVNO and a MNO identifier for uniquely identifying the MNO are used. Furthermore, it is assumed that mobile terminals **1** registered as users of the MVNO, that is, mobile terminals **1***a* and **1***c* (see FIG. **4**), store a MVNO identifier (MVNO_ID) for identifying the MVNO in which the mobile terminals **1***a* and **1***c* are registered. It is also assumed that mobile terminals **1** registered as users of the MNO, that is, mobile terminals **1***b* and **1***d* (see FIG. **4**), store a MNO identifier for identifying the MNO in which the mobile terminals **1***b* and **1***d* are registered. MS stands for Mobile Station.

The ASN **11** includes the base stations (**2**, **20**) and the ASNGW **3**, and is configured to perform processing relating to radio access. The MNO base station **2** and the MVNO base station **20** provide radio access to the mobile terminals **1** by, for example, relaying control messages such as authentication request messages. The MNO base station **2** and the MVNO base station **20** are assigned base station identifiers for base station identity. In the following description, the MNO base station **2** may also be referred to as a "MNO base station" to clarify the difference between the MNO base station **2** and the MVNO base station **20**. The MNO base station may notify the mobile terminals **1** of information about service regarding communication performed via the MNO base station, as described below.

The MVNO base station **20** may set a billing condition for the use of the MVNO base station **20** in accordance with the setting conditions notified by the H-AAA server **5**. The MVNO base station **20** may also notify the mobile terminals **1** of service information such as the content of service or a billing condition for communication performed via the MVNO base station **20**.

The ASNGW **3** supports or manages authentication, and determines the authentication device to which an authentication request message received from a mobile terminal **1** is transferred to in accordance with, for example, the base station through which the authentication request message has passed. The ASNGW **3** stores information of the base stations such as at least the base station identifier of the MVNO base station **20** connected to the ASNGW **3**. The ASNGW **3** also stores a MVNO identifier for identifying the MVNO that provides communication service via the MVNO base station **20**. Further, the ASNGW **3** stores the MNO identifier of the MNO that permits the transfer of a control message received via the MVNO base station **20** when service is provided to a user of the MNO via the MVNO base station **20**.

The ASNGW **3** transfers the control message received via the MVNO base station **20** to the MVNO A H-AAA server **5** of the MVNO. Here, the ASNGW **3** may also be designed to transfer the control message to the H-AAA server **5** of the MVNO when a MVNO identifier or the MNO identifier of the MNO that permits the transfer of the control message is assigned. In contrast, upon receipt of a control message via

the MNO base station **2**, the ASNGW **3** transfers the control message to the H-AAA server **6** of the MNO. The transfer of the control message is described in detail below. The ASNGW **3** may store the MVNO identifier or the MNO identifier in a memory in table or database form.

The ASNGW **3** may also record in a table or a database a terminal identifier for specifying a mobile terminal of a MNO user or a MVNO user who is permitted to perform communication via the MVNO base station **20**, and may store the terminal identifier in the memory. Further, the ASNGW **3** may perform processes such as processes for billing information, management of radio resource, management of transmission resource, processes regarding handover or location update, and termination of radio-related functionality. While specific processes are described herein as examples, the present invention is not limited to performing any particular type of process.

The CSN **12** includes the P-AAA server **4**, the H-AAA server **6**, and a Home Agent (HA) **7**, which are used to perform processes such as connection to the Internet, connection to the MVNO network **13**, authentication using an authentication server, and home agent processes based on the Mobile Internet Protocol (IP).

The P-AAA server **4** and the H-AAA server **6** of the MNO perform an authentication or billing process on MNO users. As described below, for example, upon receipt of an authentication request from the ASNGW **3**, the P-AAA server **4** transfers an authentication request sent from a MNO user to the H-AAA server **6** of the MNO, and transfers an authentication request sent from a MVNO user to the H-AAA server **5** of the MVNO. The H-AAA server **6** of the MNO processes an authentication request, a billing request, or the like transferred from the P-AAA server **4** or the H-AAA server **5** of the MVNO to perform authentication or billing on MNO users. The home agent **7** registers the mobile terminals **1** or manages position information. The home agent **7** further intercepts packets transmitted to the mobile terminals **1** or packets transmitted from the mobile terminals **1**, and relays the intercepted packets to the destination such as the mobile terminals **1**.

The MVNO network **13** is a network provided by the MVNO, and includes the H-AAA server **5** of the MVNO. The H-AAA server **5** of the MVNO performs authentication and billing on MVNO users. In addition, for example, the H-AAA server **5** may also notify the H-AAA server **6** of the MNO of an authentication request from a MNO user or a calculated amount to be charged for the use by a MNO user. Further, the H-AAA server **5** may set a billing condition suitable for the MVNO base station **20**. For example, the H-AAA server **5** may set an additional fee for a MVNO base station **20** that is installed in a less accessible region such as an island or a mountainous region, and may send the setting to the MVNO base station **20**.

An operation performed in Case **1** when the mobile terminal **1***a* that is a MVNO user terminal requests authentication via the MVNO base station **20** will now be described with reference to FIG. **2**.

First, the mobile terminal **1***a* located in the communication area of the MVNO base station **20** is connected to the MVNO base station **20**. The MVNO base station **20** notifies the mobile terminal **1***a* of a base station identifier for identifying the MVNO base station **20** using, for example, a notification signal or the like before a connection is established with the mobile terminal **1***a*. When a connection is established between the mobile terminal **1***a* and the MVNO base station **20**, the mobile terminal **1***a* establishes a radio link with the ASNGW **3**.

When a radio link is established with the ASNGW **3**, the mobile terminal **1***a* generates an authentication request message for requesting the MVNO in which the mobile terminal **1***a* is registered as a user to authenticate the mobile terminal **1***a*. The authentication request message includes the base station identifier of the MVNO base station **20** connected to the mobile terminal **1***a*, and the MVNO identifier for identifying the MVNO requested by the mobile terminal **1***a* to perform authentication. The mobile terminal **1***a* transmits the authentication request message to the ASNGW **3** via the MVNO base station **20**.

The ASNGW **3** specifies the base station through which the received authentication request message has passed on the basis of the base station identifier included in the received authentication request message. Upon recognition that the authentication request message has passed through the MVNO base station **20**, the ASNGW **3** determines that the authentication request message is transferred to the H-AAA server **5** of the MVNO. Then, it is determined whether or not the MVNO identifier included in the authentication request message is equal to the MVNO identifier of the MVNO determined by the ASNGW **3** as the transfer destination of the authentication request message. When the MVNO identifier is equal to (matches) the identifier of the transfer destination of the authentication request message, the ASNGW **3** transfers the authentication request message to the H-AAA server **5** of the MVNO.

Upon receipt of the authentication request message from the ASNGW **3**, the H-AAA server **5** of the MVNO authenticates the mobile terminal **1***a*, and transmits an authentication response message to the ASNGW **3**. The ASNGW **3** transfers the response message to the mobile terminal **1***a* via the MVNO base station **20**. When authentication has succeeded, the communication service to the mobile terminal **1***a* is started via the MVNO base station **20**.

With the use of the above authentication method, the H-AAA server **5** of the MVNO may receive an authentication request message directly from the ASNGW **3**. Thus, the information used by the H-AAA server **5** for authentication or the authentication request message may have a different configuration from information or a message used by the H-AAA server **6** of the MNO.

FIG. **3** is a sequence diagram illustrating an example of an operation for authentication and billing of a mobile terminal **1** via the MVNO base station **20**. The authentication and billing involved when the mobile terminal **1***a* performs communication via the MVNO base station **20** will be described with reference to FIG. **3**.

(1) A radio link is established between the mobile terminal **1***a* and the ASNGW **3**. As described above, before a radio link is established, the mobile terminal **1***a* is connected to the MVNO base station **20** located between the mobile terminal **1***a* and the ASNGW **3**, and obtains the base station identifier of the MVNO base station **20**.

(2) The mobile terminal **1***a* transmits an authentication request message to the ASNGW **3**. The authentication request message includes a base station identifier for identifying the MVNO base station **20** and a MVNO identifier.

(3) The ASNGW **3** compares the base station identifier included in the received authentication request message with the base station identifier stored in advance, and determines whether or not the received authentication request message has passed through the MVNO base station **20**. Alternatively, when the ASNGW **3** stores the relationship between the numbers of ports and the base stations (**2**, **20**) connected to the ports, the ASNGW **3** may determine whether or not the received authentication request message has passed through

the MVNO base station **20** on the basis of the number of the port through which the authentication request message has been received.

Then, the ASNGW **3** checks the MVNO identifier, and determines whether or not the authentication request message is transferred. Here, it is assumed that the authentication request message includes the MVNO identifier of the MVNO to which the ASNGW **3** transfers the authentication request message and that it is determined that the authentication request message is transferred to the H-AAA server **5**. Note that the ASNGW **3** may discard an authentication request message that is not transferred to the H-AAA server **5**.

(4) The ASNGW **3** transfers the authentication request message including the MVNO identifier to the H-AAA server **5** of the MVNO.

(5) The H-AAA server **5** of the MVNO compares the MVNO identifier assigned to the MVNO that operates the H-AAA server **5** with the MVNO identifier included in the authentication request message, and checks whether both match. When the MVNO identifiers match, the H-AAA server **5** determines whether or not the access from the mobile terminal **1***a* is permitted on the basis of the received authentication request message, and transmits an authentication response message to the ASNGW **3**. Here, it is assumed that the access from the mobile terminal **1***a* is permitted.

(6) The ASNGW **3** transfers the authentication response message to the mobile terminal **1***a* via the MVNO base station **20**.

(7) When the access is permitted, the mobile terminal **1***a* queries the ASNGW **3** about an assigned IP address using, for example, the Dynamic Host Configuration Protocol (DHCP). When the mobile terminal **1***a* is informed of the assigned IP address, a connection is established between the home agent **7** that transfers packets to the mobile terminal **1***a* and the ASNGW **3**.

(8) The ASNGW **3** transmits a billing start request message to the H-AAA server **5**.

(9) The H-AAA server **5** transmits a billing start response message to the ASNGW **3** in response to the billing start request message, and starts billing for the communication of the mobile terminal **1***a*.

(10) The mobile terminal **1***a* performs user data communication with the communication destination such as the counterpart terminal via the home agent **7**. During the user data communication, the H-AAA server **5** may receive a notification of information used for the calculation of an amount to be charged from the ASNGW **3**, the MVNO base station **20**, or the like. In this case, the H-AAA server **5** requests the ASNGW **3** or the MVNO base station **20** to transmit the information used for the calculation of the amount to be charged in accordance with the setting of the MVNO. For example, the H-AAA server **5** may specify, as the information used for the calculation of the amount to be charged, the use status such as the number of packets used by the mobile terminal **1***a* or the communication time, the base station identifier of the MVNO base station **20**, and the like.

(11) When the mobile terminal **1***a* completes the communication, the mobile terminal **1***a* transmits a disconnection request message to the ASNGW **3**, and the ASNGW **3** transmits a disconnection response message to the mobile terminal **1***a*.

(12) When the mobile terminal **1***a* completes the communication, the ASNGW **3** transmits a billing stop request message to the H-AAA server **5**. The ASNGW **3** may notify the H-AAA server **5** of the use status such as the number of packets or the call time when transmitting a billing stop request message.

(13) Then H-AAA server **5** calculates the amount to be charged on the basis of the use status or the like. Further, the H-AAA server **5** transmits a billing stop response message to the ASNGW **3**, and the billing-related process ends.

Accordingly, during authentication or billing, an authentication request message or a billing start request message is transmitted from the ASNGW **3** directly to the H-AAA server **5**. Therefore, the information used by the H-AAA server **5** about authentication or billing of access from the mobile terminal **1***a* that performs communication via the MVNO base station **20** may be different from the information sent to the P-AAA server **4** of the MNO. Thus, for example, the MVNO may take a billing method or an authentication method that is different from the billing method or authentication method of the MNO. For example, the MVNO may change the amount to be charged in accordance with the place where the MVNO base station **20** is installed, and may provide a modified billing rate such as a phone call fee discount for a limited time or additional charge for donation for a limited time, regardless of the billing condition of the MNO.

In the operation described in Case **1**, the ASNGW **3** selects an authentication request message to be transferred in procedure (3). In this manner, the ASNGW **3** selects a control message to be processed, thereby preventing a control message that is not processed by the H-AAA server **5** or **6** from being transferred to the H-AAA server **5**. Therefore, the process of the ASNGW **3** may reduce the load on the H-AAA server **5**.

An operation performed in Case **2** when the mobile terminal **1***b* that is a MNO user terminal requests authentication via the MVNO base station **20** will now be described with reference to FIG. **2**. Note that the MVNO may reject the authentication of the mobile terminal **1***b* of the MNO user via the MVNO base station **20**. When the authentication of the mobile terminal **1***b* is rejected, the operation of Case **2** is not performed.

First, the mobile terminal **1***b* located in the communication area of the MVNO base station **20** is connected to the MVNO base station **20**, and establishes a radio link with the ASNGW **3**. As in Case **1**, the mobile terminal **1***b* is notified of a base station identifier for identifying the MVNO base station **20** using, for example, a notification signal or the like, and the establishment of a radio link is also performed in a procedure similar to that of Case **1**.

Then, the mobile terminal **1***b* creates an authentication request message including the base station identifier of the MVNO base station **20** and a MNO identifier, and transmits the authentication request message to the ASNGW **3** via the MVNO base station **20**. Upon receipt of the authentication request message including the base station identifier of the MVNO base station **20**, the ASNGW **3** determines that the transfer destination is the H-AAA server **5** of the MVNO. Further, the ASNGW **3** compares the MNO identifier included in the authentication request message with the MNO identifier stored in advance, and determines whether or not the authentication request message is transferred. When both match, the ASNGW **3** transfers the authentication request message to the H-AAA server **5** of the MVNO.

Upon receipt of the authentication request message from the ASNGW **3**, the H-AAA server **5** of the MVNO determines whether the authentication request message includes a MVNO identifier or a MNO identifier. Upon detection of a MNO identifier, the H-AAA server **5** determines that the mobile terminal **1***b* is a mobile terminal **1** of a MNO user.

The H-AAA server **5** of the MVNO transfers the authentication request message about the access from the mobile terminal **1***b* to the H-AAA server **6** of the MNO. The H-AAA

server **6** of the MNO authenticates the mobile terminal **1***b*, and transmits an authentication response message to the H-AAA server **5** of the MVNO. The H-AAA server **5** of the MVNO transfers the authentication response message to the ASNGW **3**, and the ASNGW **3** transfers the authentication response message to the mobile terminal **1***b* via the MVNO base station **20**. When authentication has succeeded, the communication service to the mobile terminal **1***b* is started via the MVNO base station **20**.

The authentication and billing procedure involved when the mobile terminal **1***b* performs communication via the MVNO base station **20** will be described with reference to FIG. **3**. In Case **2**, in addition to the operation performed in Case **1**, operations indicated by dotted blocks in FIG. **3** are performed. The establishment of a radio link between the MVNO base station **20** and the mobile terminal **1***b* is performed in a way similar to that in procedure (1) described in Case **1**.

(2) The mobile terminal **1***b* transmits an authentication request message to the ASNGW **3**. The authentication request message includes a base station identifier for identifying the MVNO base station **20** and a MNO identifier.

(3) The ASNGW **3** recognizes that an authentication request message that has passed through the MVNO base station **20** has been received using the base station identifier. Then, the ASNGW **3** checks the MNO identifier, and determines whether or not the authentication request message is transferred. Here, it is assumed that a setting is made so that the ASNGW **3** transfers an authentication request message of a MNO user and that the authentication request message is to be transferred to the H-AAA server **5**.

(4) The ASNGW **3** transfers the authentication request message including the MNO identifier to the H-AAA server **5** of the MVNO.

(4a) The H-AAA server **5** of the MVNO transfers the authentication request message including the MNO identifier to the H-AAA server **6** of the MNO. The H-AAA server **6** of the MNO authenticates the mobile terminal **1***b*. Here, it is assumed that the access from the mobile terminal **1***b* is authorized.

(4b) The H-AAA server **6** of the MNO transmits an authentication response message to the H-AAA server **5** of the MVNO.

(5) The H-AAA server **5** of the MVNO transfers the authentication response message to the ASNGW **3**.

The procedure from the operation for transferring the authentication response message from the ASNGW **3** to the mobile terminal **1***b* to the operation for transmitting a billing start request message to the H-AAA server **5** is similar to that in procedures (6) to (8) described in Case **1**.

(8a) The H-AAA server **5** of the MVNO transfers the billing start request message to the H-AAA server **6** of the MNO.

(8b) The H-AAA server **6** of the MNO transmits a billing start response message to the H-AAA server **5** of the MVNO in response to the billing start request message.

(9) The H-AAA server **5** of the MVNO transfers the billing start response message to the ASNGW **3**, and performs a process for calculating the amount to be charged for the communication of the mobile terminal **1***b*. That is, the H-AAA server **5** of the MVNO calculates the amount to be charged for the use of service by the mobile terminal **1***b* on behalf of the H-AAA server **6** of the MNO.

(10) The mobile terminal **1***b* performs user data communication with the communication destination such as the counterpart terminal via the home agent **7**. During the user data communication, the H-AAA server **5** of the MVNO receives a notification of information used for the calculation of the amount to be charged from the ASNGW **3**, the MVNO base station **20**, or the like. As in Case **1**, the information used for the calculation of the amount to be charged may be information corresponding to the setting of the MVNO.

(11) When the mobile terminal **1***b* completes the communication, the mobile terminal **1***b* transmits a disconnection request message to the ASNGW **3**, and the ASNGW **3** transmits a disconnection response message to the mobile terminal **1***b*.

(12) When the mobile terminal **1***b* completes the communication, the ASNGW **3** transmits a billing stop request message to the H-AAA server **5**.

(12a) The H-AAA server **5** of the MVNO transfers the billing stop request message to the H-AAA server **6** of the MNO. When the H-AAA server **5** of the MVNO calculates the amount to be charged for the communication of the mobile terminal **1***b* before the billing stop request message is transferred, the H-AAA server **6** of the MNO may be notified of the amount to be charged together with the billing stop request message.

(12b) Upon receipt of the billing stop request message, the H-AAA server **6** of the MNO transmits a billing stop response message to the H-AAA server **5** of the MVNO.

(13) The H-AAA server **5** of the MVNO transfers the billing stop response message to the ASNGW **3**. The H-AAA server **5** of the MVNO may also transfer the billing stop response message and then calculate the amount to be charged to the mobile terminal **1***b*.

Accordingly, during the authentication or billing of a MNO user, an authentication request message or a billing start request message is transmitted to the H-AAA server **5** of the MVNO, and is then transferred to the H-AAA server **6** of the MNO. Therefore, the MNO selects information used for the authentication of a user accessing via the MVNO base station **20** from the information included in the authentication request message received by the H-AAA server **5** of the MVNO. Furthermore, since the H-AAA server **5** of the MVNO calculates the amount to be charged, even when the MNO and the MVNO calculate the amount to be charged or the like using different methods, the amount to be charged for the communication of the mobile terminal **1***b* is calculated using a calculation method used by the MVNO.

When the ASNGW **3** stores the terminal identifier of the MNO user who is permitted to perform communication via the MVNO base station **20**, the ASNGW **3** compares the terminal identifier included in the authentication request message with the stored terminal identifier in procedure (3). When the terminal identifier included in the authentication request message matches the terminal identifier stored in the ASNGW **3**, the authentication request message is transferred to the H-AAA server **5**. In this modification, the content of service may be changed and/or customized for each user. For example, a specific user among MNO users may be permitted to perform communication via the MVNO base station **20**.

An operation performed in Case **3** when the mobile terminal **1***c* that is a MVNO user terminal requests authentication via the base station **2** will now be described with reference to FIG. **4**.

First, the mobile terminal **1***c* located in the communication area of the MNO base station **2** is connected to the MNO base station **2**. When a connection is established between the mobile terminal **1***c* and the base station **2**, the mobile terminal **1***c* establishes a radio link with the ASNGW **3**. When a radio link is established with the ASNGW **3**, the mobile terminal **1***c* generates an authentication request message for requesting authentication, and transmits the authentication request mes-

sage to the ASNGW **3** via the MNO base station **2**. The authentication request message includes a MVNO identifier for identifying the MVNO in which the mobile terminal **1***c* is registered as a user. However, the authentication request message may not necessarily include the base station identifier of the MNO base station **2** to which the mobile terminal **1***c* is connected.

Upon confirmation that the received authentication request message includes no base station identifiers, the ASNGW **3** recognizes that the authentication request message has been transmitted via the MNO base station **2**. Then, the ASNGW **3** transfers the authentication request message to the P-AAA server **4** of the MNO.

Upon receipt of the authentication request message, the P-AAA server **4** of the MNO determines whether the mobile terminal **1***c* that is requesting authentication using the message is a mobile terminal of a MNO user or a mobile terminal of a MVNO user. In this case, when the authentication request message includes a MVNO identifier, the P-AAA server **4** determines that the authentication request message is an authentication request message sent from a MVNO user terminal. Then, the P-AAA server **4** determines that the mobile terminal **1***c* is a mobile terminal **1** of a MVNO user, and transfers the authentication request message to the H-AAA server **5** of the MVNO.

Upon receipt of the authentication request message, the H-AAA server **5** of the MVNO authenticates the mobile terminal **1***c*, and transmits an authentication response message to the P-AAA server **4**. The P-AAA server **4** transfers the response message to the mobile terminal **1***c* via the ASNGW **3** and the MNO base station **2**. When authentication has succeeded, the communication service to the mobile terminal **1***c* is started via the MNO base station **2**.

In the foregoing description, the authentication request message transmitted from the mobile terminal **1***c* includes no base station identifiers. However, the mobile terminal **1***c* may transmit an authentication request message including a base station identifier for identifying the MNO base station **2** to the ASNGW **3**. In this case, upon confirmation that the authentication request message includes the base station identifier of the MNO base station **2**, the ASNGW **3** may transmit the authentication request message to the P-AAA server **4**. That is, the ASNGW **3** may transfer a message that has passed through the MVNO base station **20** to the H-AAA server **5** (Case **1**), and may transfer a message that has passed through the MNO base station **2** to the P-AAA server **4** (Case **3**). In this manner, the ASNGW **3** may determine a transfer destination of an authentication request message in accordance with the base station through which the authentication request message has passed.

FIG. **5** is a sequence diagram illustrating an example of an operation for authentication and billing of the mobile terminal **1***c* via the MNO base station **2**. The authentication and billing involved when the mobile terminal **1***c* performs communication via the MNO base station **2** will be described with reference to FIG. **5**.

(1) A radio link is established between the mobile terminal **1***c* and the ASNGW **3**.

(2) The mobile terminal **1***c* transmits an authentication request message including a MVNO identifier to the ASNGW **3**.

(3) The ASNGW **3** transfers the authentication request message received via the MNO base station **2** to the P-AAA server **4** of the MNO. It may be determined that the authentication request message has passed through the MNO base station **2** on the basis of, as described above, the authentication request message that includes no base station identifiers.

(4) Upon detection that the mobile terminal **1***c* is a MVNO user terminal on the basis of the MVNO identifier included in the authentication request message, the P-AAA server **4** transfers the authentication request message to the H-AAA server **5** of the MVNO.

(5) The H-AAA server **5** of the MVNO determines, on the basis of the received authentication request message, whether or not the access from the mobile terminal **1***c* is permitted, and transmits an authentication response message to the P-AAA server **4** of the MNO. Here, it is assumed that the access from the mobile terminal **1***c* is permitted.

(6) The P-AAA server **4** of the MNO transfers the authentication response message to the ASNGW **3**.

(7) The ASNGW **3** transfers the authentication response message to the mobile terminal **1***c* via the MNO base station **2**.

(8) When the access is permitted, a connection is established between the mobile terminal **1***c* and the home agent **7** via the ASNGW **3** using the IP address assigned to the mobile terminal **1***c*.

(9) The ASNGW **3** transmits a billing start request message to the P-AAA server **4** of the MNO.

(10) Since the mobile terminal **1***c* is a mobile terminal **1** of a MVNO user, the P-AAA server **4** of the MNO transfers the billing start request message to the H-AAA server **5** of the MVNO.

(11) The H-AAA server **5** of the MVNO transmits a billing start response message to the P-AAA server **4** of the MNO, and starts billing for the communication of the mobile terminal **1***c*.

(12) The P-AAA server **4** of the MNO transfers the billing start response message to the ASNGW **3**.

(13) The mobile terminal **1***c* performs user data communication with the communication destination such as the counterpart terminal via the home agent **7**. During the user data communication, the H-AAA server **5** receives a notification of information used for the calculation of the amount to be charged from the ASNGW **3**, the MNO base station **2**, or the like via the P-AAA server **4**.

(14) When the mobile terminal **1***c* completes the communication, the mobile terminal **1***c* transmits a disconnection request message to the ASNGW **3**, and the ASNGW **3** transmits a disconnection response message to the mobile terminal **1***c*.

(15) When mobile terminal **1***c* completes the communication, the ASNGW **3** transmits a billing stop request message to the P-AAA server **4** of the MNO.

(16) The P-AAA server **4** of the MNO transfers the billing stop request message to the H-AAA server **5** of the MVNO.

(17) The H-AAA server **5** of the MVNO transmits a billing stop response message to the P-AAA server **4** of the MNO. The H-AAA server **5** calculates the amount to be charged on the basis of the use status or the like.

(18) The billing stop response message is transferred from the P-AAA server **4** to the ASNGW **3**, and the billing-related process ends.

An operation performed in Case **4** when the mobile terminal **1***d* that is a MNO user terminal requests authentication via the MNO base station **2** will now be described with reference to FIG. **4**. The mobile terminal **1***d* located in the communication area of the MNO base station **2** is connected to the MNO base station **2** and then establishes a radio link with the ASNGW **3**. Then, the mobile terminal **1***d* generates an authentication request message including a MNO identifier, and transmits the authentication request message to the ASNGW **3** via the MNO base station **2**.

The ASNGW **3** recognizes that the authentication request message has been transmitted via the MNO base station **2** operated by the MNO using any of the methods described in Case **3**, and transfers the authentication request message to the P-AAA server **4** of the MNO.

Upon confirmation that the authentication request message includes a MNO identifier, the P-AAA server **4** of the MNO determines that the mobile terminal **1***d* that is requesting authentication is a mobile terminal of a MNO user. Then, the P-AAA server **4** transfers the authentication request message to the H-AAA server **6** of the MNO.

Upon receipt of the authentication request message, the H-AAA server **6** of the MNO authenticates the mobile terminal **1***d*, and transmits an authentication response message to the P-AAA server **4**. The P-AAA server **4** transfers the response message to the mobile terminal **1***d* via the ASNGW **3** and the MNO base station **2**. When authentication has succeeded, the communication service to the mobile terminal **1***d* is started via the MNO base station **2**.

The operation for the authentication and billing of the mobile terminal **1***d* of the MNO user is almost similar to the operation described in Case **3** with reference to FIG. **5**. However, the authentication and billing of the MNO user is performed by the H-AAA server **6** of the MNO. Thus, the operation performed by the H-AAA server **5** of the MVNO in procedures (4), (5), (10), (11), (16), and (17) described in Case **3** is performed by the H-AAA server **6** of the MNO in Case **4**.

As described above, in the system that operates in the manner described in Cases **1** to **4**, an authentication request message transmitted to the ASNGW **3** via the MVNO base station **20** is transmitted to the H-AAA server **5** of the MVNO. That is, independently of whether a mobile terminal **1** is a MVNO user terminal or a MNO user terminal, the transfer destination of the authentication request message is determined in accordance with the base station through which the authentication request message has passed. Therefore, as described in Cases **1** and **2**, an authentication request message that has passed through the MVNO base station **20** is transferred to the H-AAA server **5** regardless of whether the authentication request message has been transmitted from a MNO user terminal or a MVNO user terminal. In the description with reference to FIGS. **2**, **3**A, **3**B, **4**, **5** and **6**, the ASNGW **3** and the like transfer a received authentication request message. However, a Remote Authentication Dial In User Service (RADIUS) message may be generated based on a received authentication request message, and may be transmitted.

As described above, an authentication request message that has passed through the MVNO base station **20** is transferred to the H-AAA server **5** of the MVNO without having to pass through the P-AAA server **4**. Thus, information used by the MVNO to perform authentication or billing for communication performed via the MVNO base station **20** may not necessarily be the same as information used by MNO to perform authentication or billing. Therefore, the MVNO may set conditions of authentication or billing for communication performed via the MVNO base station **20** at the discretion of the MVNO, and may customize the authentication or billing method as desired.

In addition, a system that operates in the manner as in Cases **1** to **4** may reduce the load on the P-AAA server **4**, which may also be beneficial to the MNO. Since an authentication request message that has passed through the MVNO base station **20** is not forwarded to the P-AAA server **4**, the P-AAA server **4** may only be required to process authentication request messages received via the MNO base station **2**. Thus, the number of messages processed by the P-AAA server **4** may be reduced. If the load on the P-AAA server **4** is increased in future due to the development of business by the MNO or MVNO, the use of the method described above may reduce the load on the P-AAA server **4**.

FIG. **6** is a diagram illustrating an example of a payment method for a fee generated by charging for communication performed via the MVNO base station **20**. When a MVNO user **31** performs communication via the MVNO base station **20**, as described in Case **1**, the H-AAA server **5** of the MVNO performs authentication and billing. Then, as illustrated in FIG. **6**, a MVNO **32** provides service to the MVNO user **31**, and the MVNO user **31** pays a user usage fee to the MVNO **32**.

In contrast, as in Case **2**, when a MNO user **33** performs communication via the MVNO base station **20**, authentication is performed by the H-AAA server **6** of the MNO. When the authentication has succeeded in the H-AAA server **6**, the MVNO **32** provides, on behalf of a MNO **34**, communication (substitute service) to the mobile terminal **1***b* via the MVNO base station **20**. Furthermore, the H-AAA server **5** of the MVNO calculates a usage fee for the substitute service. Then, in the relationship between the MVNO **32** and the MNO user **33**, as illustrated in FIG. **6**, the MVNO **32** provides communication service to the MNO user **33** and calculates the amount to be charged. The MNO user **33** pays the user usage fee to the MNO **34**. Here, even when the MNO user **33** receives service from the MVNO **32** instead of the MNO **34**, the MNO user **33** does not pay the usage fee directly to the MVNO **32** because there is no contract between the MNO user **33** and the MVNO **32**.

The MNO **34** that has received the user usage fee from the MNO user **33** pays a usage fee for the substitute service, which has been provided to the MNO user **33**, to the MVNO **32**. Since the MVNO **32** leases a Radio Access Network (RAN) from the MNO **34** to provide service, the MVNO **32** pays a RAN connection fee to the MNO **34**. Depending on the agreements or the like between the MNO **34** and the MVNO **32**, the MVNO **32** may pay the balance between the MNO user's usage fee and the RAN connection fee to the MNO **34**.

In calculating an amount to be charged, the MVNO **32** may calculate a usage fee for the substitute service provided to the MNO user **33** using a method different from that for the user usage fee of the MVNO user **31**. Further, the billing method may be based on any of packet-based charging and time-based charging. The amount to be charged may be calculated based on any pricing structure such as a flat-rate pricing structure, a metered-rate pricing structure, or a price cap plan structure. Data used for the calculation of the amount to be charged, such as the communication time or the number of communication packets, may be managed by the MVNO base station **20** or by the ASNGW **3**. The H-AAA server **5** of the MVNO calculates the amount to be charged on the basis of the information obtained from the MVNO base station **20** or the ASNGW **3**, and sends the amount to be charged to the H-AAA server **6** of the MNO **34**.

FIG. **7** is a flowchart illustrating an example of the operation of the ASNGW **3**. Operation S**11** to S**13** and S**17** are performed by the ASNGW **3** in Cases **3** and **4**. Operation S**11**, S**12**, and S**14** to S**17** represent the operation in Case **1**. Operation S**11**, S**12**, and S**14** to S**18** represent the operation in Case **2**. In the example illustrated in FIG. **7**, it is assumed that an authentication request message transmitted from a mobile terminal **1** to the ASNGW **3** includes a base station identifier for identifying the MVNO base station **20** or a MNO base station identifier for identifying the MNO base station **2**. In the illustration of FIG. **7**, the ASNGW **3** generates an

RADIUS message based on a received authentication request message, and transmits the RADIUS message to the P-AAA server **4** or the H-AAA server **5**.

Upon receipt of an authentication request message from the mobile terminal **1**, the ASNGW **3** checks the base station identifier or MNO base station identifier included in the authentication request message, and determines whether or not the authentication request message has been received via the MVNO base station **20** (operation S**11** and S**12**). When the authentication request message has been received via the MNO base station **2**, the ASNGW **3** transmits a RADIUS message created based on the received authentication request message to the P-AAA server **4** (operation S**13** and S**17**).

When the authentication request message has been received from the MVNO base station **20**, on the other hand, the ASNGW **3** compares the MVNO identifier included in the authentication request message with the MVNO identifier stored in the ASNGW **3** (operation S**14**). When both match, the ASNGW **3** adds information about the H-AAA server **5** of the MVNO to a RADIUS message created based on the received authentication request message, and transmits the resulting RADIUS message to the H-AAA server **5** (operation S**15** to S**17**).

When the MVNO identifier included in the authentication request message received from the MVNO base station **20** is different from the MVNO identifier stored in the ASNGW **3**, the mobile terminal **1** that has transmitted the authentication request message is a MNO user terminal. Thus, when the MVNO identifier included in the authentication request message is different from the stored identifier, it is determined whether or not a connection from the MNO user is permitted (operation S**18**). When a connection from the MNO user is permitted, the RADIUS message is transmitted to the H-AAA server **5** of the MVNO (operation S**15** to S**17**). When a connection from the MNO user is not permitted, the connection is rejected and the process ends (operation S**19**). When the connection is rejected, an error message may be transmitted to the mobile terminal **1**, or the operation of the ASNGW **3** may be terminated without informing the mobile terminal **1** of the rejection.

As described above, an authentication request message that has passed through the MVNO base station **20** is directly processed by the H-AAA server **5** of the MVNO. Thus, the MVNO may customize the method of authentication or billing via the MVNO base station **20** as desired. For example, a usage fee may be changed in accordance with the condition of the MVNO base station **20**, and the MVNO base station **20** installed in a region where it is difficult to build a communication infrastructure, such as an island or a mountainous region, may use an additional pricing option. Thus, a commercially viable pricing structure may be realized. With the use of the method of an embodiment, the MVNO may develop business using the MVNO base station **20** in an island or the like, thereby overcoming the digital divide. In addition, in an area within which the MVNO wishes to increase market share, conversely, the MVNO may set a discount rate for communication performed via the MVNO base station **20** situated in a target area.

Such billing conditions for each MVNO base station **20** may be collectively set or changed by the H-AAA server **5**, and an operator at the H-AAA server **5** may perform setting using a desired user interface or command. Furthermore, a plurality of billing conditions may be prepared in advance in the H-AAA server **5**, and when a billing condition is set or changed, the H-AAA server **5** may send a notification of a suitable billing condition to the MVNO base station **20** for which the setting is made. Moreover, the H-AAA server **5** may also set or change billing conditions per unit of areas.

Here, it may be desirable that MVNOs inform users of a billing rate different from a normal fee, such as a discount fee or an additional fee. For example, the application of a discount fee may be indicated with a visual marker or the like on the mobile terminals **1** to facilitate user recognition. This may involve a potential increase in advertising awareness. Further, the mobile terminals **1** may be informed of the application of an additional fee, thus avoiding trouble over fees charged to users. Further, in a system, desirably, a user located in communication areas of a plurality of base stations having different billing conditions is allowed to select a desired base station as the connection destination.

Accordingly, a system that allows the MVNO base station **20** or the MNO base station **2** to notify the mobile terminals **1** of conditions relating to connections, such as billing conditions, and that allows users to select a desired base station will now be described with reference to FIGS. **8** to **15**. With the use of the method described below, a MVNO may provide service that allows a MVNO user to select a base station to which a mobile terminal **1** is to be connected. In this system, furthermore, the MVNO may contract with a specific MNO user to allow the contracted MNO user to select a base station.

FIG. **8** is a diagram illustrating an example of a method for allowing (enabling) the mobile terminal **1***a* to select a desired base station. In an embodiment, it is assumed that the mobile terminal **1***a* is located in a communication area covered by both base stations, namely, the MNO base station **2** and the MVNO base station **20**. The MVNO base station **20** and the MNO base station **2** notify, when transmitting a notification signal, the mobile terminal **1***a* of service available via the MVNO base station **20** and the MNO base station **2** and conditions such as billing conditions. The mobile terminal **1***a* selects a desired base station as the connection destination in accordance with a predetermined connection policy, and transmits a ranging message (Initial Ranging). When the mobile terminal **1***a* has no predetermined connection policy, conditions sent from the MVNO base station **20** and the MNO base station **2** may be displayed on a screen provided in the mobile terminal **1***a*, and a desired base station may be selected in accordance with a user input.

FIG. **9** is a sequence diagram illustrating an example of an operation performed when the mobile terminal **1***a* selects a desired base station. The mobile terminal **1***a* is located in the communication area of overlapping coverage of the two base stations, namely, the MNO base station **2** and the MVNO base station **20**, and receives notification signals from both the MNO base station **2** and the MVNO base station **20**. The example in FIG. **9** illustrates a case where service information received from the MNO base station **2** is compared with service information received from the MVNO base station **20** and where the mobile terminal **1***a* is connected to the MVNO base station **20**.

(1) As indicated in (1a) and (1b), the MNO base station **2** and the MVNO base station **20** broadcast notification signals. Each of the notification signals includes a Downlink Channel Descriptor (DCD) message, an Uplink Channel Descriptor (UCD) message, a Downlink Mapping (DL-MAP) message, an Uplink Mapping (UL-MAP) message, and service information. The MNO base station **2** and the MVNO base station **20** include base station identifiers for identifying the MNO base station **2** and the MVNO base station **20**, respectively, in the notification signals which are transmitted. Each of the base station identifiers may be implemented using, for example, but not limited to, a Code-Division Multiple Access

(CDMA) code. Each of the base station identifiers may be an identifier capable of uniquely specifying a base station.

Here, the service information includes desired conditions that may be used by the mobile terminal **1***a* to select a desired base station as the connection destination, such as, for example, but not limited to, a pricing structure applied when the base station is used, available service, and throughput. The DCD message defines characteristics of the downlink physical layer, and the UCD message defines characteristics of the uplink physical layer. The DL-MAP message includes downlink burst allocation information, and the UL-MAP message includes uplink burst allocation information.

FIG. **10** is a diagram illustrating an example of a notification signal **40** broadcast from a base station. The notification signal **40** includes a header **41**, message content **42**, a check field **43**, and a service information field **44**. The header **41** and the message content **42** (**42***a*, **42***b*) include information indicating that the signal is the notification signal **40**, the DCD message, the UCD message, the DL-MAP message, the UL-MAP message, and any other suitable messages. The check field **43** is a field indicating whether or not service information is being transmitted, and the mobile terminal **1***a* checks the check field **43** to recognize whether or not the service information field **44** includes service information. For example, when the service information field **44** includes service information, all the bits of the check field **43** may be "1". Accordingly, the base stations (**2**, **20**) and the mobile terminal **1***a* recognize in advance the value of the check field **43** that includes service information. A procedure in which the mobile terminal **1***a* selects a desired base station as the connection destination using the service information will be described in detail below.

(2) As indicated in (2a) and (2b), the MNO base station **2** and the MVNO base station **20** broadcast the UL-MAP messages. The mobile terminal **1***a* obtains from the UL-MAP messages the intervals during which the MNO base station **2** and the MVNO base station **20** perform initial ranging.

(3) The mobile terminal **1***a* compares the content of the service information transmitted from each of the MNO base station **2** and the MVNO base station **20** with the connection policy of the mobile terminal **1***a*, and determines a desired base station (BS) as the connection destination. FIG. **11** is a diagram illustrating an example of a service information field and the connection policy of the mobile terminal **1***a*. Here, it is assumed that the notification signal **40** transmitted from the MNO base station **2** includes a service information field **44***a* and that the notification signal **40** transmitted from the MVNO base station **20** includes a service information field **44***b*. It is also assumed that the example of the connection policy of the mobile terminal **1***a*, when represented using a scheme written in the service information field **44**, may be represented in a manner as in a service information field **44***c*. In the illustrated example, the mobile terminal **1***a* does not use services A, C, and D but uses a service B. Thus, upon receipt of the notification signals **40** from the MNO base station **2** and the MVNO base station **20**, the mobile terminal **1***a* checks the service information fields **44***a* and **44***b* in the received messages, and searches for a base station that is available to provide the service B. As illustrated in FIG. **11**, the MNO base station **2** is not available to provide the service B but the MVNO base station **20** is available to provide the service B. Thus, the mobile terminal **1***a* selects the MVNO base station **20** as the connection destination.

(4) The mobile terminal **1** transmits an Initial Ranging message to the MVNO base station **20** that has been determined as the connection destination. In this case, the mobile terminal **1** includes a base station identifier for identifying the MVNO base station **20** in the Initial Ranging message. The mobile terminal **1** does not send a response to the MNO base station **2** that is not determined as the connection destination.

(5) The MVNO base station **20** checks the radio status of the mobile terminal **1***a* from the Initial Ranging message, and transmits a Ranging Response (RNG RES) message to the mobile terminal **1***a*. When the radio status of the mobile terminal **1** meets the condition required by the MVNO base station **20**, the MVNO base station **20** transmits a message indicating "Success" to the mobile terminal **1***a*. When the radio status of the mobile terminal **1***a* is outside the condition required by the MVNO base station **20**, the MVNO base station **20** transmits a message indicating "Abort" or "Continue" to the mobile terminal **1***a*.

(6) When the message indicating "Success" is transmitted to the mobile terminal **1***a*, the MVNO base station **20** records the success of ranging in CDMA Allocation included in the UL-MAP message, which is transmitted to the mobile terminal **1***a*.

(7) The mobile terminal **1***a* transmits a Ranging Request (RNG REQ) message to the MVNO base station **20**, and enters a bandwidth allocation procedure.

(8) The MVNO base station **20** transmits a RNG RES message to the mobile terminal **1***a* to inform the mobile terminal **1***a* of the Radio Frequency (RF) power level adjustment value, the frequency offset value, the timing offset value, and any other suitable value.

(9) A connection is established between the mobile terminal **1***a* and the MVNO base station **20**, and the mobile terminal **1***a* performs an authentication response message process with the H-AAA server **5** of the MVNO via the MVNO base station **20**.

FIG. **12** is a flowchart illustrating an example of the operation of a base station in a connection method that allows the selection of a base station. Each of the base stations (**2**, **20**) broadcasts service information together with a DCD message, a UCD message, a DL-MAP message, and a UL-MAP message to inform the mobile terminal **1** located in the communication area of service information such as available service (operation S**21**). A base station that has received an Initial Ranging message from the mobile terminal **1***a* performs a connection process of the mobile terminal **1***a* (operation S**22** and S**23**).

FIG. **13** is a flowchart illustrating an example of the operation of the mobile terminal **1***a* in a connection method that allows the selection of a base station. The mobile terminal **1***a* compares service information received from the base stations (**2**, **20**) with the connection policy, and determines a desired base station as the connection destination (operation S**31**). Then, the mobile terminal **1***a* transmits an Initial Ranging message to the base station selected as the connection destination, and performs a connection process (operation S**32** and S**33**).

With the use of the above method, users such as MVNO users and contracted MNO users are provided with a connection method that allows the selection of a base station. In the procedure (3) described with reference to FIG. **11**, the mobile terminal **1***a* selects a desired base station as the connection destination in accordance with the connection policy stored therein. Alternatively, the mobile terminal **1***a* may select a desired base station as the connection destination in accordance with a user input. In this case, for example, base stations that may be connected to the mobile terminal **1***a* and fees applied in each of the base stations are displayed on the screen. Then, when the user selects the MVNO base station **20** to which a discount fee is applied, in procedure (4), the

mobile terminal **1***a* transmits an Initial Ranging message to the selected MVNO base station **20**.

The example in which the MVNO base station **20** that is available to provide the service desired by the mobile terminal **1***a* exists has been described with reference to FIG. **11**. However, neither the MNO base station **2** nor the MVNO base station **20** to which the mobile terminal **1***a* may be connected may meet the connection condition of the mobile terminal **1***a*. Thus, when none of the base stations (**2**, **20**) is available to provide the desired service, the mobile terminal **1***a* may additionally store a condition for selecting a base station. For example, priorities may be set for the services in order with the service B given the highest priority and the service A, the service C, and the service D given subsequent priorities in descending order. When there is no base station that is available to provide the service B, the mobile terminal **1***a* may be connected to a base station that is available to provide the service A.

The connection method may also be set on the basis of the billing condition in addition to the service type. For example, a setting may be made so that the mobile terminal **1***a* is connected to a base station to which a normal fee or a discount fee is applied but not to a base station to which an additional fee is applied. Further, billing condition priorities may be given to "discount fee", "normal fee", and "additional fee" in descending order, and the mobile terminal **1***a* may be connected to a base station to which the additional fee is applied unless a base station to which the normal fee is applied exists.

FIG. **14** is a diagram illustrating an example of an operation performed when the mobile terminal **1***b* is connected to a base station. Here, it is assumed that the mobile terminal **1***b* is a mobile terminal **1** that does not support the notification of service information for selecting a desired base station. Thus, even upon receipt of the notification signal **40** indicating that the check field **43** includes service information, the mobile terminal **1***b* does not select a desired base station as the connection destination using the content of the service information field **44**. A base station to which the mobile terminal **1***b* is to be connected is determined in accordance with the intensity or the like of the notification signal **40** transmitted from the MNO base station **2** or the MVNO base station **20**.

FIG. **15** is a sequence diagram illustrating an example of an operation performed when the mobile terminal **1***b* is connected to a base station.

(1) As indicated in procedures (1a) and (1b), the MNO base station **2** and the MVNO base station **20** broadcast notification signals. Each of the notification signals includes a DCD message, a UCD message, a DL-MAP message, a UL-MAP message, and a base station identifier.

(2) As indicated in procedures (2a) and (2b), the MNO base station **2** and the MVNO base station **20** broadcast the UL-MAP messages.

(3) The mobile terminal **1***b* obtains from the UL-MAP messages the intervals during which the MNO base station **2** and the MVNO base station **20** perform initial ranging. Further, the mobile terminal **1***b* selects a desired base station as the connection destination on the basis of the intensity or the like of the notification signals received in procedure (1), and transmits an Initial Ranging message to the selected base station. Here, since the mobile terminal **1***b* is a mobile terminal **1** that does not support the notification of service information, service information is not used for the selection of a base station even when the service information is included in the service information field **44**.

The operation in procedures (4) to (8) is similar to that in procedures (5) to (9) described with reference to FIG. **9**. The MVNO base station **20** which is the connection destination transmits an RNG RSP message indicating "Success" and CDMA Allocation to the mobile terminal **1***b*. When band allocation and the notification of the frequency offset values and the like are completed between the mobile terminal **1***b* and the MVNO base station **20**, the mobile terminal **1***b* performs an authentication response message process with the H-AAA server **5** via the MVNO base station **20**.

Accordingly, since the presence of service information is checked using the check field **43**, the mobile terminals **1** may be notified of service information using the notification signal **40** without interference with the operation of the mobile terminals **1** if the mobile terminals **1** do not use the service information to select a base station.

The present invention is not to be limited to the foregoing embodiments, and a variety of modifications may be made. Some examples will now be described.

In the foregoing description, one MVNO is used. An exemplary modification of the operation in Case **1** for performing authentication when a first MVNO and a second MVNO provide individual service and the MVNO base station **20** is operated by the first MVNO will now be described. In this exemplary modification, the first MVNO may prevent the second MVNO from providing service using the MVNO base station **20**. In this case, the ASNGW **3** stores in advance an identifier for identifying the first MVNO as the identifier of a company that operates an object to which a control message is transferred, but does not store the MVNO identifier of the second MVNO.

In procedure (3) in Case **1**, the ASNGW **3** checks the MVNO identifier included in the authentication request message, and determines whether or not the MVNO identifier specifies a company that operates an object to which a control message is transferred. For example, when the MVNO base station **20** is specified by the base station identifier and the MVNO identifier indicates the first MVNO, the ASNGW **3** transmits an authentication request message to the H-AAA server **5** of the first MVNO. When the MVNO identifier included in the authentication request message that specifies the MVNO base station **20** is an identifier for identifying the second MVNO, the ASNGW **3** rejects authentication, and does not transfer the authentication request message.

With the above exemplary modification, in an area where a plurality of MVNOs develop business, the first MVNO may reject authentication or billing of users of other MVNOs.

Furthermore, a modification of the operation described in Case **2** may allow authentication of a mobile terminal **1** of a user of a MVNO different from the MVNO that operates the MVNO base station **20**. That is, access from a mobile terminal **1** of a user of a third MVNO is authorized via the MVNO base station **20** of the first MVNO using an operation similar to the operation described in Case **2**. In this case, the MVNO identifier of the third MVNO that permits user communication may be registered in advance in the ASNGW **3**. Then, the user of the third MVNO whose MVNO identifier has been registered may be authorized, and the amount to be charged thereto may be calculated. In such a case, the first MVNO notifies the third MVNO of the amount to be charged calculated by the H-AAA server **5**, and the usage fee of the MVNO base station **20** may be collected from the third MVNO.

In addition, any of the foregoing embodiments may also be implemented using mobile IPs, and may be implemented using a desired radio interface standardized in International Mobile Telecommunications-2000 (IMT-2000).

In FIG. **2**, a system in which the home agent **7** is provided in the CSN **12** has been described by way of example. However, the home agent **7** may be provided in the MVNO network **13**.

Further, in the illustration of FIGS. **2**, **3**A, **3**B, **4** and **5**, each of the mobile terminals **1** is notified of a base station identifier using a notification signal, by way of example. The MNO base station **2** or the MVNO base station **20** may also notify each of the mobile terminals **1** of a base station identifier using any control signal other than a notification signal.

Further, in any of Cases **1** to **4**, the ASNGW **3** may store the relationship between the numbers of ports and the base stations (**2**, **20**) connected to the ports. In this case, the ASNGW **3** may also determine whether or not an authentication request message has passed through the MVNO base station **20** on the basis of the number of the port at which the authentication request message has been received. That is, the ASNGW **3** may be modified so as to determine from which base station of the MNO base station **2** and the MVNO base station **20** a control message has been received without using a base station identifier. The relationship between the numbers of the ports and the base stations (**2**, **20**) connected to the ports may also be stored as a table in a memory of the ASNGW **3**.

Accordingly, there is provided an authentication and billing method in which an authentication request received by a relay device via the MVNO base station **20** is transferred to the H-AAA server **5** of the MVNO regardless of whether the authentication request is an authentication request from a MVNO user or an authentication request from a MNO user. The H-AAA server **5** of the MVNO determines whether or not access is permitted in response to an authentication request transmitted from a MVNO user. Further, the H-AAA server **5** transfers an authentication request transmitted from a MNO user to the H-AAA server **6** of the MNO. With the use of the above method, the MVNO may set or change information used by the MVNO for authentication and billing regardless of the authentication and billing method performed by the MNO. That is, the MVNO may customize the billing method or the authentication method as desired.

According to an embodiment, a computer implemented method of managing a service to a mobile terminal includes receiving a request including from the mobile terminal using a leased base station configured to provide a service, and determining a transfer destination of the request based on a base station through which the authentication request message has passed. A relay device may be located between a first base station or a second base station configured to selectively provide a service of a mobile network operator and an authentication device or an authentication device managed by the mobile network operator.

The embodiments can be implemented in computing hardware (computing apparatus) and/or software, such as (in a non-limiting example) any computer that can store, retrieve, process and/or output data and/or communicate with other computers. The results produced can be displayed on a display of the computing hardware. A program/software implementing the embodiments may be recorded on computer-readable media comprising computer-readable recording media. The program/software implementing the embodiments may also be transmitted over transmission communication media. Examples of the computer-readable recording media include a magnetic recording apparatus, an optical disk, a magneto-optical disk, and/or a semiconductor memory (for example, RAM, ROM, etc.). Examples of the magnetic recording apparatus include a hard disk device (HDD), a flexible disk (FD), and a magnetic tape (MT). Examples of the optical disk include a DVD (Digital Versatile Disc), a DVD-RAM, a CD-ROM (Compact Disc-Read Only Memory), and a CD-R (Recordable)/RW. An example of communication media includes a carrier-wave signal.

Further, according to an aspect of the embodiments, any combinations of the described features, functions and/or operations can be provided.

All examples and conditional language recited herein are intended for pedagogical purpose to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present inventions have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention, the scope of which is defined in the claims and their equivalents.

What is claimed is:

1. A method of authenticating a mobile terminal using a Mobile Virtual Network Operator (MVNO) authentication device managed by a mobile virtual network operator, the method comprising:

receiving an authentication request sent from the mobile terminal from a relay device via a MVNO base station configured to provide a service of the mobile virtual network operator, the relay device being located between the MVNO base station or a Mobile Network Operator (MNO) base station configured to provide a service of a mobile network operator and the MVNO authentication device or a MNO authentication device managed by the mobile network operator, the authentication request including a mobile virtual network operator identifier identifying a mobile virtual network operator and a base station identifier identifying the MVNO or MVO base station via which the authentication request is transmitted from the mobile terminal to the relay device;

determining whether access from the mobile terminal serving as a MVNO mobile terminal registered as a user of the mobile virtual network operator is permitted, based on the mobile virtual network operator identifier included in authentication request; and

transferring, upon receiving the authentication request sent from a MNO mobile terminal registered as a user of the mobile network operator from the relay device, the authentication request to the MNO authentication device.

2. The method according to claim **1**, comprising:

calculating an amount to be charged to the MVNO mobile terminal from which access is permitted in accordance with the base station identifier, and

wherein the authentication request includes the base station identifier, and the base station identifier is configured to identify the MVNO base station, or the MNO base station that relays the authentication request.

3. The method according to claim **2**, comprising:

calculating an amount to be charged to the MNO mobile terminal from which access is permitted in accordance with the base station identifier when providing the service via the MVNO base station to a MNO mobile terminal registered as a user of the mobile network operator, and

notifying the MNO authentication device of the amount to be charged.

4. A method for authenticating a mobile terminal using a relay device, the method comprising:

receiving, by the relay device, an authentication request sent from the mobile terminal via a Mobile Virtual Net-

work Operator (MVNO) base station configured to provide a service of a mobile virtual network operator or a Mobile Network Operator (MNO) base station configured to provide a service of a mobile network operator, the relay device being located between the MVNO base station or the MNO base station and a MVNO authentication device managed by the mobile virtual network operator or a MNO authentication device managed by the mobile network operator, the authentication request including a mobile virtual network operator identifier identifying a mobile virtual network operator or a mobile network operator identifier identifying a mobile network operator, and a base station identifier identifying the MVNO or MVO base station via which the authentication request is transmitted from the mobile terminal to the relay device;

determining via which of the MVNO base station and the MNO base station the authentication request has been received, based on the base station identifier included in the authentication request;

transferring the authentication request to the MVNO authentication device to determine whether access from the mobile terminal serving as a MVNO mobile terminal registered as a user of the mobile virtual network operator is permitted, based on the mobile virtual network operator identifier included in the authentication request, upon receipt of the authentication request via the MVNO base station; and

transferring the authentication request to the MNO authentication device to determine whether access from the mobile terminal serving as a MNO mobile terminal registered as a user of the mobile network operator is permitted, based on the mobile network operator identifier included in the authentication request, upon receiving the authentication request via the MNO base station.

5. The method according to claim **4**, comprising:

transmitting the MNO authentication request to the MVNO authentication device to transfer the MNO authentication request to the MNO authentication device upon receipt of a MNO authentication request for requesting the mobile network operator to perform authentication from a MNO mobile terminal registered as a user of the mobile network operator via the MVNO base station.

6. The method according to claim **4**, comprising:

storing a terminal identifier for identifying a MVNO-base-station-associated MNO mobile terminal that is registered as a user of the mobile network operator and that represents a mobile terminal configured to receive a service via the MVNO base station;

determining whether a mobile terminal that has transmitted the authentication request is the MVNO-base-station-associated MNO mobile terminal using the terminal identifier upon receipt of an authentication request for using the service of the mobile network operator via the MVNO base station; and

discarding the authentication request in a case where the authentication request is not transmitted from the MVNO-base-station-associated MNO mobile terminal.

7. The method according to claim **4**, comprising:

causing the MVNO base station or the MNO base station to notify the mobile terminal of service information indicating a condition of service provided through communication performed via the MVNO base station or the MNO base station.

8. The method according to claim **5**, comprising:

causing the MVNO base station or the MNO base station to notify the mobile terminal of service information indicating a condition of service provided through communication performed via the MVNO base station or the MNO base station.

9. The method according to claim **6**, comprising:

causing the MVNO base station or the MNO base station to notify the mobile terminal of service information indicating a condition of service provided through communication performed via the MVNO base station or the MNO base station.

10. A mobile terminal authentication system, comprising:

a Mobile Virtual Network Operator (MVNO) base station configured to provide a service of a mobile virtual network operator;

a Mobile Network Operator (MNO) base station configured to provide a service of a mobile network operator;

a MVNO authentication device configured to be managed by the mobile virtual network operator;

a MNO authentication device configured to be managed by the mobile network operator; and

a relay device configured to execute an operation including:

receiving an authentication request from a mobile terminal via the MVNO base station or the MNO base station, the authentication request including a mobile virtual network operator identifier identifying the mobile virtual network operator or a mobile network operator identifier identifying a mobile network operator, and a base station identifier identifying the MVNO or MVO base station via which the authentication request is transmitted from the mobile terminal to the relay device,

transferring the authentication request to the MVNO authentication device to determine whether access from the mobile terminal serving as a MVNO mobile terminal registered as a user of the mobile virtual network operator is permitted, based on the mobile virtual network operator identifier included in the authentication request upon receiving the authentication request via the MVNO base station, and

transferring the authentication request to the MNO authentication device to determine whether access from the mobile terminal serving as a MNO mobile terminal registered as a user of the mobile network operator is permitted, based on the mobile network operator identifier included in the authentication request, upon receiving the authentication request via the MNO base station.

11. The authentication system according to claim **10**, wherein the authentication request includes the base station identifier for identifying the MVNO base station or the MNO base station that relays the authentication request, and

wherein the MVNO authentication device calculates an amount to be charged to the MVNO mobile terminal from which access has been permitted in accordance with the base station identifier.

12. The authentication system according to claim **10**, wherein the MVNO authentication device calculates, when providing service to a MNO mobile terminal registered as a user of the mobile network operator via the MVNO base station, an amount to be charged to the MNO mobile terminal from which access has been permitted in accordance with the base station identifier, and notifies the MNO authentication device of the amount to be charged.

13. The authentication system according to claim 10, wherein upon receipt of an authentication request transmitted from a MNO mobile terminal registered as a user of the mobile network operator, the MVNO authentication device transfers the authentication request transmitted from the MNO mobile terminal to the MNO authentication device.

14. The authentication system according to claim 10, wherein the relay device causes the MVNO base station or the MNO base station to notify the mobile terminal of service information indicating a condition of service provided through communication performed via one of the MVNO base station or the MNO base station.

* * * * *